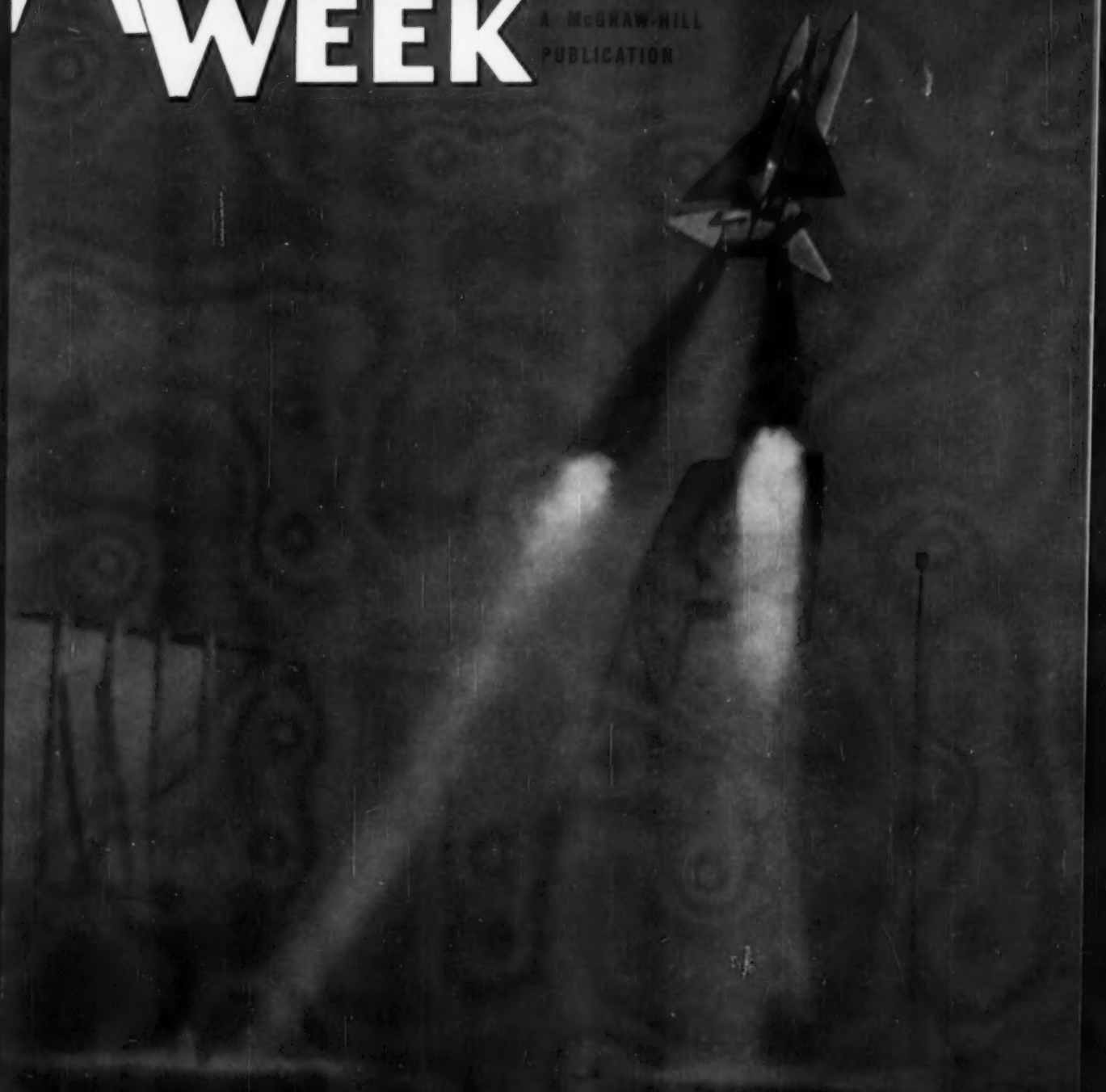
JUNE 3, 1957

THIS ISSUE $3.00

AVIATION WEEK

A McGRAW-HILL PUBLICATION



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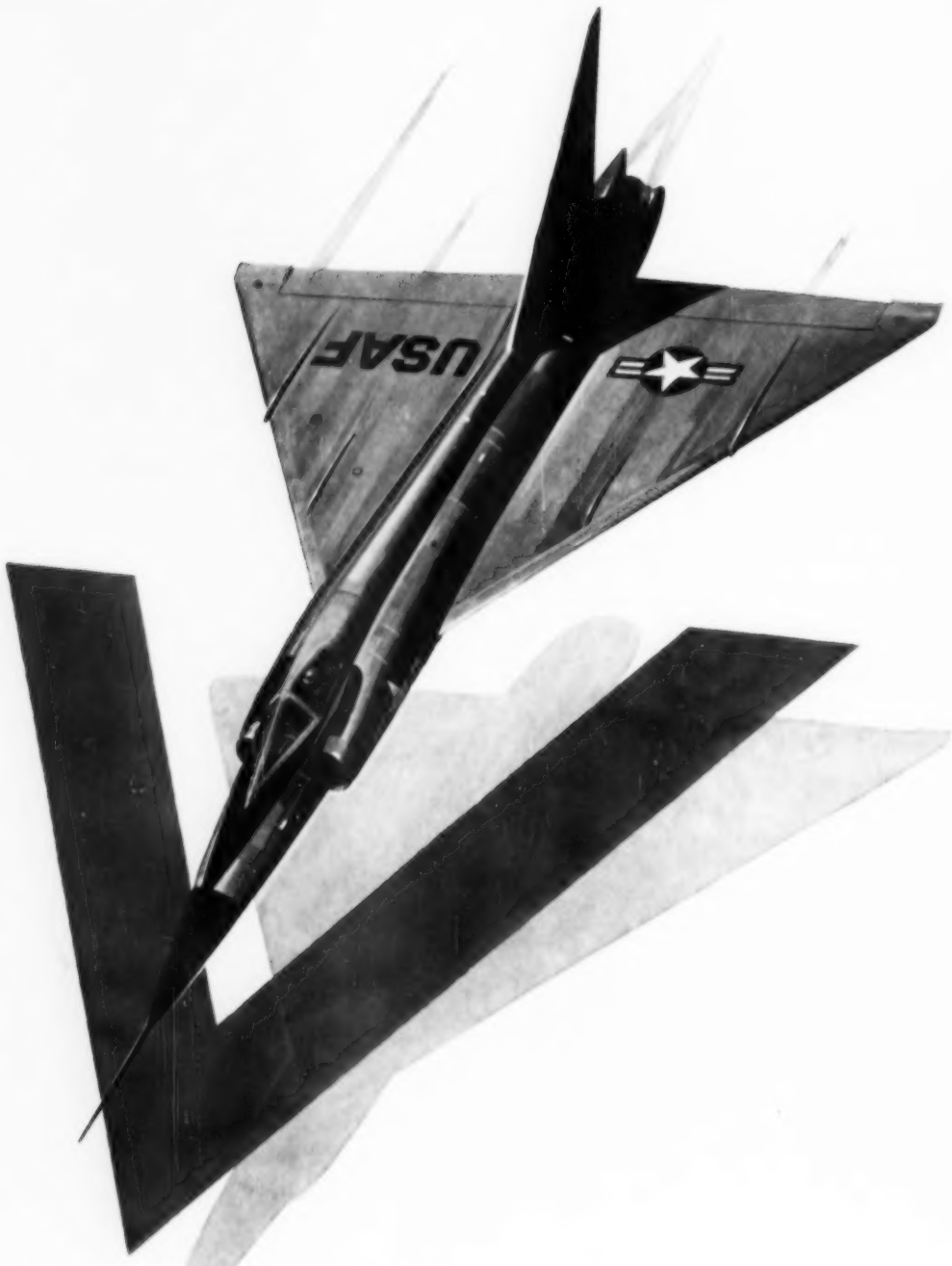

V FOR VICTORY

△ FOR CONVAIR'S DELTA-WING F-102A

Hallmarks of Freedom

Delta...the shape that won a striking victory in performance on both sides of the sonic barrier, is your *new* hallmark of freedom! Flying around the clock with the U.S. Air Force, Convair's supersonic F-102A all-weather Interceptor affords you security never before attained by our air defense system. Master of any invading aircraft, the *delta*-wing F-102A is another outstanding example of Convair's *engineering to the Nth power.*

CONVAIR

A DIVISION OF GENERAL DYNAMICS CORPORATION

Circle Number 1 on Reader-Service Card

TEXAS

Lone Star

From the Rio Grande to the hills of New England, the Fairchild F-27 outshines anything in its class. This exciting new prop-jetliner gives today's airlines equipment modern as tomorrow.

Seating up to 40 passengers in its pressurized cabin, it flies smoothly and quietly on the propjet power of its airline-proven Rolls-Royce Dart engines—gets in and out of short fields with ease. Airfields at altitude rarely impose a payload penalty on the F-27—and single-propjet performance is superb.

Also available as a truly unique executive transport, the F-27 is a practical flying office for executives on the go.

Address inquiries to: R. James Pfeiffer, Executive Director of Customer Relations, Fairchild Engine and Airplane Corporation, Hagerstown 15, Maryland.

FAIRCHILD

F-27

THE FINEST AIRCRAFT FOR AIRLINES, CORPORATIONS AND MILITARY SERVICES.

Circle Number 2 on Reader-Service Card

NEW

Trans-Sonics*

"TAPE-ON" SURFACE TEMPERATURE RESISTORS

for Temperature Telemetering

- NO THICKER THAN A PIECE OF TAPE
- OUTPUT UP TO 5 VOLTS WITHOUT AMPLIFICATION
- AVAILABLE IN VARIOUS RANGES FROM −300° to +400°F.
- RESISTANCE CHANGE OF 100 OHMS OVER SPECIFIED RANGE
- NO HOLES TO DRILL — QUICK AND EASY "TAPE-ON" INSTALLATION

Trans-Sonics Type 1371 "Tape-on" Surface Temperature Resistors are precision resistance thermometers with a platinum resistance winding as the sensing element. These resistors which are no thicker than a piece of tape may be applied to *any surface* whose temperatures are to be measured. In a commutation circuit, they modulate standard telemetering transmitters without amplification. The new Type 1371 "Tape-on" Surface Temperature Resistors may be added to an installation using other Trans-Sonics temperature transducers without any further circuit modification. Each resistor is furnished with 6" long fibreglas-covered constantan leads. Write for Bulletin 1371 to Trans-Sonics, Inc., Dept. 7.

*Reg. Trademark

SPECIFICATIONS

SIZE: ¼" x 5/16"

Accuracy: ±2% of full scale range

Precision: ±0.5% of full scale range

Maximum Continuous Current: 20 ma rms (averaged over 1 second)

Environmental Operation Conditions

Vibration: 1" double amplitude, 0 to 22 cps ± 25g, 22 to 2000 cps

Shock: 100g in any direction, per paragraph 4.15.1 of MIL-E-5272A (10 milliseconds shock)

INSTANT INSTALLATION

As easy to apply as a thumb print.

For Transducers, See Trans-Sonics

Trans-Sonics, Inc.

P. O. BOX 328 LEXINGTON 73, MASSACHUSETTS

Circle Number 3 on Reader-Service Card

AVIATION WEEK • JUNE 3, 1957

Vol. 66, N. 22

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Single Copies 50¢. Subscription rates—United States and possessions, $6 a year. Canada $8 a year.

Second class mail privileges authorized at Albany 1, N. Y. Printed in U. S. A.

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Fulcher Armstrong, pioneer airman, now owner of the Wichita Falls Air Transport Company which operates the municipal airport.

Built his first plane himself... now he rides herd on one of Texas' busiest airports

Two major air lines, Braniff and Continental, are served by the Wichita Falls Air Transport Company.

Home on the range: Private aircraft from all over the Southwest enjoy the complete line service offered.

Back in the early days of flying, Fulcher Armstrong built his own airplane and flew it successfully. Later he was one of the first to visualize the advantages of using airplanes in the ranching business and commuted from Wichita Falls to ranches in New Mexico. In 1927 he built his own airport to accommodate his aircraft. Three years later, the city of Wichita Falls asked him to convert his facility to a municipal airport. Beginning with this small operation, Mr. Armstrong has built it into one of the finest airports in the Southwest.

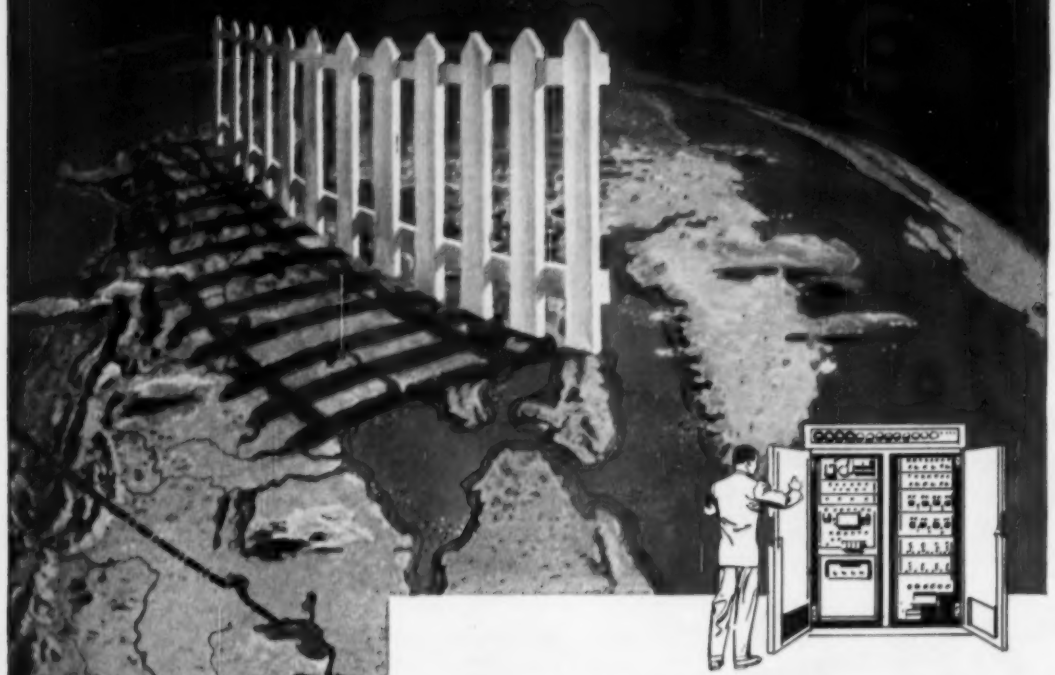
At present, the Wichita Falls Air Transport Company offers, on a 24-hour basis, complete line service for private planes and airliners; major and minor repairs on all types of planes up to and including Convairs; charter and ambulance flights, and radio repair. In addition, Armstrong's company operates a pipe line patrol and a flying school.

Phillips 66 Aviation Gasoline is used exclusively. "We find that Phillips 66 gasoline gives dependable performance. That's what counts with our customers," Mr. Armstrong says.

AVIATION DIVISION • PHILLIPS PETROLEUM COMPANY • BARTLESVILLE, OKLAHOMA

Circle Number 4 on Reader-Service Card

MOTOROLA RADAR PICKETS IN THE "DEW-LINE" FENCE



Stretching 3,000 miles across the Arctic, special Motorola radar systems stand alert, ready to sound a warning at the first indication of an air attack over the polar cap.

The urgency of this distant early warning system called for a "crash" program for both development and production. Working in turn with the Lincoln Laboratories at M.I.T., Bell Telephone Laboratories, and the Western Electric Company, Inc., Motorola engineers came through with radar systems for the complete line within a 14-month period.

This is only one example of the military electronic equipment being developed and produced by Motorola for the varied military applications.

Positions open to qualified Engineers and Physicists

MOTOROLA

MILITARY ELECTRONICS DIVISION

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Motorola is ready to help you on all phases of military electronics

Navigational Systems

Field Engineering

Communications

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Missile Systems and Components

Electronic Countermeasures

Component Design

Radar

Intelligence Systems

Electronic Computers

Beacons

Circle Number 5 on Reader-Service Card

"TRIGGER FINGER" FOR SAC

Reliable protection is a *must* for Boeing's giant B-52, operational weapon of the Strategic Air Command. An Avco-Crosley-manufactured MD-9 fire control system—with dual radar and multi-weapon turret—provides deadly, and almost completely automatic protection for the B-52.

This newest "stinger" is one of a long list of modern bomber defense systems produced by Crosley. And, looking to the future, Crosley scientists are constantly developing still finer protection for the aircraft of tomorrow.

Crosley offers complete facilities for research, development, and production of:

Air Weapons Systems
Ground Radar Systems
Air Traffic Control Systems
Ordnance Systems
Missile Systems
Aircraft Structures
Communications Systems
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Avco Manufacturing Corporation,
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defense and industrial products

ENGINEERS WANTED: For top-flight men, Crosley offers unusual opportunities to explore new scientific frontiers that lead to outstanding and rewarding careers. Write to Vice President of Engineering at Avco-Crosley.

Circle Number 6 on Reader-Service Card

new

a single or multiple disconnect using seamless, crimp-type terminations

UNILOK — HALF THE SIZE AND WEIGHT OF COMPARABLE *AN* CONNECTORS

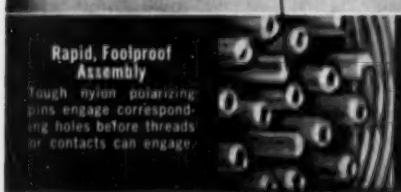
In one compact unit, conforming to standard AN connector mounting dimensions, UNILOK offers the advantages of a ring connector, or a separable connector for each circuit. Small terminals allow completed harness to be pulled through openings no larger than the cable bundle itself. Circuit checks are simple in either fully or partially assembled UNILOKS.

Easy Circuit Check
Probes reach insulation grip of socket terminating each wire. Printed numbers on all faces of plug and receptacle make circuit identification simple.

Quick Multiple or Individual Connections
Any wire is easily inserted or removed from plug individually. Each contact clearly identified on all six faces of plugs and receptacle.

Crimped Terminations
Each connector is crimped on the insulation as well as on the wire. Provides maximum mechanical and electrical efficiency. Eliminates need for cable grip.

Rapid, Foolproof Assembly
Tough nylon polarizing pins engage corresponding holes before threads or contacts can engage.



Short Circuit Prevention
Recessed pins eliminate possibility of shorts from accidental contact of plug and receptacle.

High Pullout Resistance
Pull-out from plug (in excess of 50 pounds) is maintained by compression spring locks. Lock is quickly freed for wire removal by small screwdriver or knife blade.

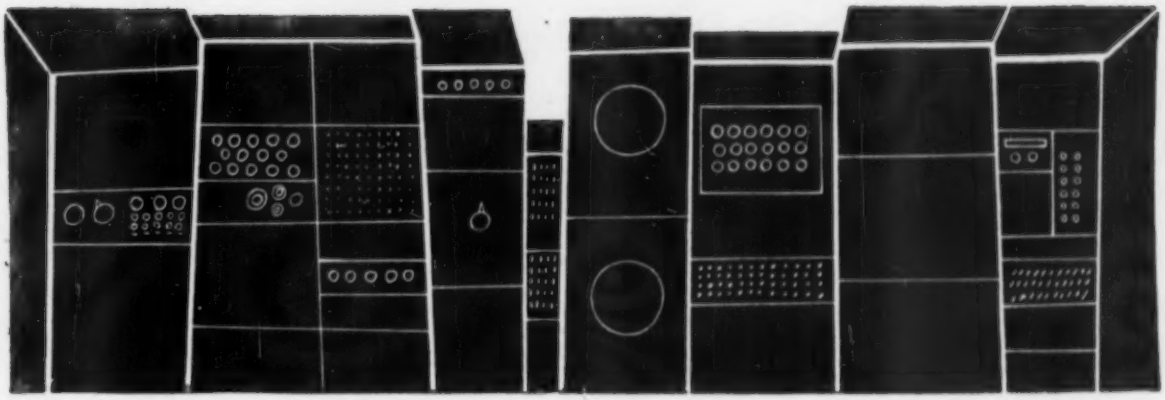
- saves weight
- saves space
- simplifies installation and maintenance on all pressurized bulkheads

New Burndy UNILOK weighs only ½ of equivalent AN connectors. Fewer parts—needs no integral cable clamp. No solder, no dissimilar metals near contacts. No metal housing to collect moisture—no corrosion products between pins. Easier to stock—assemble—service. For complete details, write Burndy—Norwalk, Connect., Toronto, Canada; Factories: New York, California, Toronto. Export: Philips Export Company.

BURNDY

Circle Number 7 on Reader-Service Card

simple as a desk calculator...



intelligent as an electronic brain!

the E101

combines advantages of both . . . and solves the problems "in-between," at low cost and with big savings in technical man-hours. Pinboard programming – an exclusive feature of the E101 digital computer – can be mastered in six hours; familiar notations, no coding. That's why more E101's are *at work* than all other comparable computers combined. Immediate delivery; instant serviceability. As a test: send us one of *your* problems. We'll program it, send your solution and proof of how we can serve. For demonstration, or descriptive booklet, write:

ElectroData

Division of Burroughs Corporation
with world-wide sales and service facilities
460 Sierra Madre Villa
Pasadena, California

Circle Number 8 on Reader-Service Card

A brand new concept in

modern day hangars...

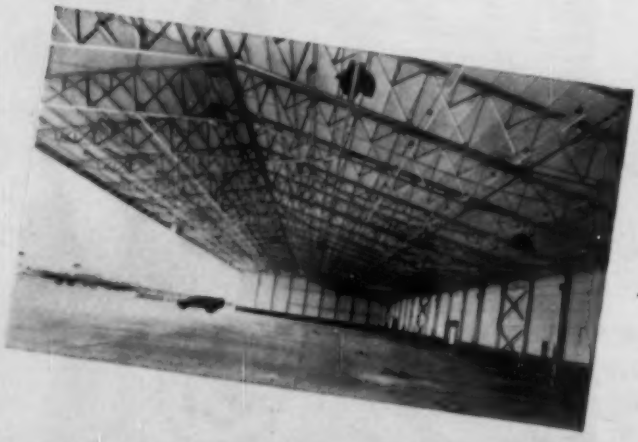
ERWIN-NEWMAN SUSPENDED CANTILEVER HANGARS

Most revolutionary development in the last fifty years

Cantilever type construction means that no columns of any nature interrupt the clear span space. EVERY square foot of hangar space is a square foot of usable space. The support member which connects the top ridge of the cantilever to the top of the inner column is designed to act either in tension or compression and will withstand wind uplift of hurricane force winds.

ANY HEIGHT • ANY LENGTH • ANY DEPTH

Each hangar is specifically designed for the snow and roof loads of the area in which it is erected. The space at the rear is conveniently used for workshops, parts and offices.



Night view of TEMCO AIRCRAFT CORP. hangar at Greenville, Texas. The clear span area measures 120 feet deep by 576 feet long by 30 feet high. Vertical clearance is 45 feet inside the tail housings.

TYPICAL QUOTES FROM SATISFIED USERS INCLUDE:

Mr. E. F. Buehring, Plant Manager, TEMCO AIRCRAFT CORP., says, "The cantilever type hangar constructed by your company has proved to be highly satisfactory for our aircraft overhaul and modification program."

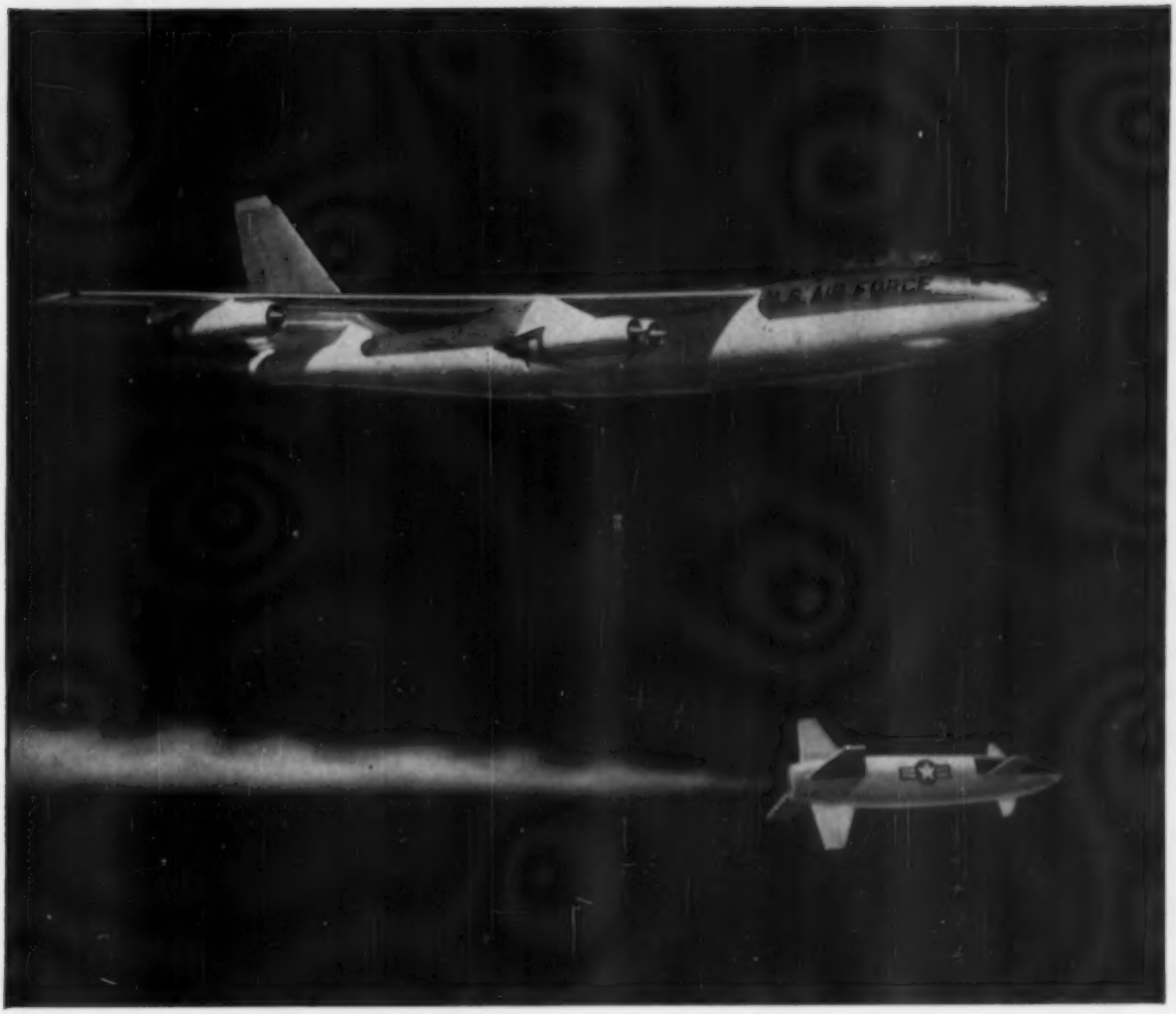
Mr. C. F. Zimmerman, Supt. Aviation Operations, CONTINENTAL OIL CO., remarked, "It is our opinion that this hangar constructed by your firm has measured up to our expectations and fulfills all of our requirements."

Write us for free booklet or any other information you desire

THE ERWIN-NEWMAN CO.

Designers and Constructors

P. O. BOX 1308 • PHONE JAckson 4-8186 • HOUSTON, TEXAS



Launched toward the Future in WEAPON SYSTEMS MANAGEMENT

Rascal—GAM-63 air-to-surface missile of the USAF—is an operational example of complete weapon systems management by Bell Aircraft. As prime contractor, Bell's responsibilities embraced the design, development, and production of the entire system including airframe, guidance, rocket engine, servo-mechanical devices, launching and ground support equipment as well as flight testing and training.

The personnel responsible for this successful program has recently been regrouped to form a new, autonamous *Guided Missiles Division.* Its sole function is to provide complete and coordinated management and production for any weapon systems program.

The men who make up this division are a skilled and diversified team of specialists with a total of some 100,000 man-years of experience in guided missiles. Prior to "Rascal", they were responsible for Tarzan, Shrike and Meteor. Current responsibilities also include important components for the Nike, Hustler, Regulus, Navaho and various I. C. B. M. and I. R. B. M. programs.

These men have past success to attest to their capabilities and foretell future accomplishments. They will be heard from again and again for important achievements in the years ahead.

BELL Aircraft CORP

Guided Missiles Div.
BUFFALO, N. Y.

With crane and bosun chair, workmen wash and wax 38-foot high tail of prop-jet C-130 Hercules transport

THE LOCKHEED C-130 HERCULES IS THE ONLY COMBAT CARGO TRANSPORT IN USAF SERVICE THAT CAN PARADROP 20-TON LOADS AT THE TOUCH OF A PUSH-BUTTON. THIS NEW PROP-JET "STRONG-MAN" OF THE AIR IS BUILT BY LOCKHEED'S GEORGIA DIVISION.

LOCKHEED *means leadership*

BALLISTIC MISSILE RESEARCH & DEVELOPMENT • ROCKETRY • WEAPON SYSTEMS MANAGEMENT • NUCLEAR-POWERED FLIGHT • ADVANCED ELECTRONICS • ANTI-SUBMARINE PATROL AIRCRAFT • LONG RANGE EARLY-WARNING RADAR CONSTELLATIONS • JET FIGHTERS • JET TRAINERS • COMMERCIAL & MILITARY PROP-JETS • LUXURY LINERS

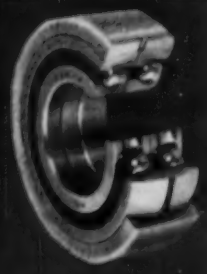
Circle Number 11 on Reader Service Card

Aircraft Bearings by Fafnir

Products that reflect close collaboration with the aircraft industry for nearly 30 years

JET ENGINE BEARINGS

For main rotor shafts of jet engines, all such bearings are designed and constructed to meet individual specifications. The bearing illustrated is a "custom tailored" super-precision ball bearing which features close dimensional tolerances, high finishes, and special construction for maximum performance and to insure absolute reliability.



DSRP SERIES AIRFRAME CONTROL BEARINGS

These bearings offer "the most capacity for weight and size" . . . a series that is clean in design and balanced in capacity. Their features include a full complement of precision rollers, large roller-to-race contact areas on both inner and outer rings plus exceptional protection against possible damage to seals in case of severe misalignment.

Y-PWI SERIES CYCLIC PITCH CONTROL BEARINGS

Especially designed for swash plate applications in helicopters, the Y-PWI series consists of a matched pair of thin section, angular contact-type bearings equipped with Fafnir patented Piya-Seals. All exposed surfaces as mounted are cadmium plated. Bearings are prepacked with lubricant conforming to the latest military specifications.

EXTRA SMALL SERIES BEARINGS

Designed for use on actuators, automatic pilots and other precision aircraft instruments, the extra small series bearings are available in metric bore sizes down to 4 mm and in inch sizes to ⅛". They are also available with standard, special or super-precision tolerances in various constructions, and they can be fitted with various combinations of seals and shields.

BALANCED-DESIGN SERIES ROD ENDS

This is the only series of rod end control bearings with three-way-balance design providing strength and capacity without excess weight. In the series, there are three sizes of high capacity roller-type rod ends for power-operated control systems and two sizes of ball bearing rod ends with high-strength shanks for manually operated control systems.

TORQUE-TUBE TYPE BEARINGS

The KP-BS Series was developed specifically for hinge applications and push-pull controls where saving in weight is essential without any reduction in bearing capacity. The self-aligning feature plus Piya-Seals permit simplification of application. The Piya-Seals are retained by stainless steel snap washers. All exposed surfaces as mounted are cadmium plated.

B500DD SERIES BEARINGS

Positive protection against contaminants and retention of lubricant are the outstanding features of this extra thin section, torque tube type series. These advantages make possible the use of simply designed, space and weight saving housings. Shields are non-metallic, close-clearance type. All exposed surfaces as mounted are cadmium plated. This series is dimensionally interchangeable with the B500 series.

FAFNIR

AIRCRAFT BEARINGS

FIRST . . . at the turning points in aircraft design

THE FAFNIR BEARING COMPANY, NEW BRITAIN, CONN.

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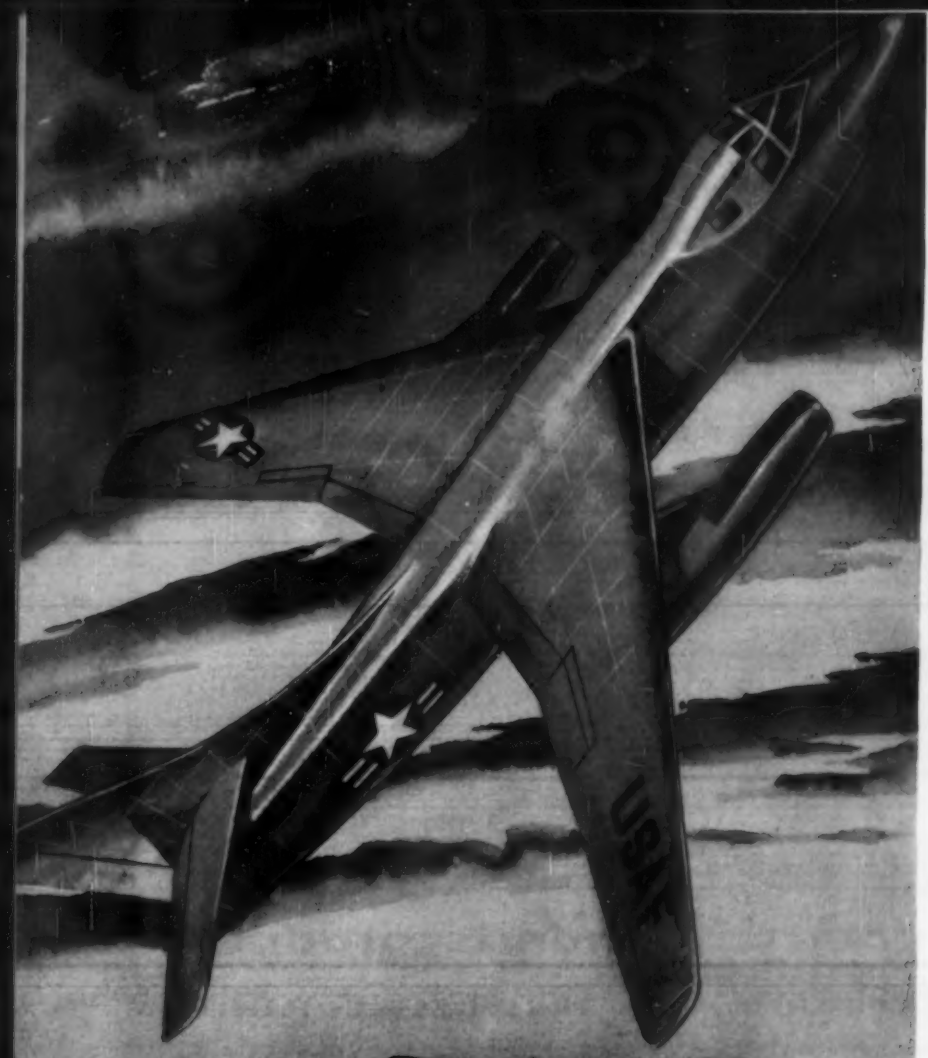


Power for Pneumatic Systems

WALTER KIDDE
4-D COMPRESSOR
Smaller than a basketball
. . . yet packed with power.

with smaller, lighter parts

EASTERN BEARING
LUBRICATION PUMP
Small enough to hide in one hand! Only 10 ozs.

The Walter Kidde 4-D Compressor gives 11¼ pounds of pneumatic power in a space 10" square. This light, small unit is a masterpiece of engineering requiring small components. The Eastern Lubrication Pump has what it takes for this task. A bantam in size and weight . . . a heavyweight in performance.

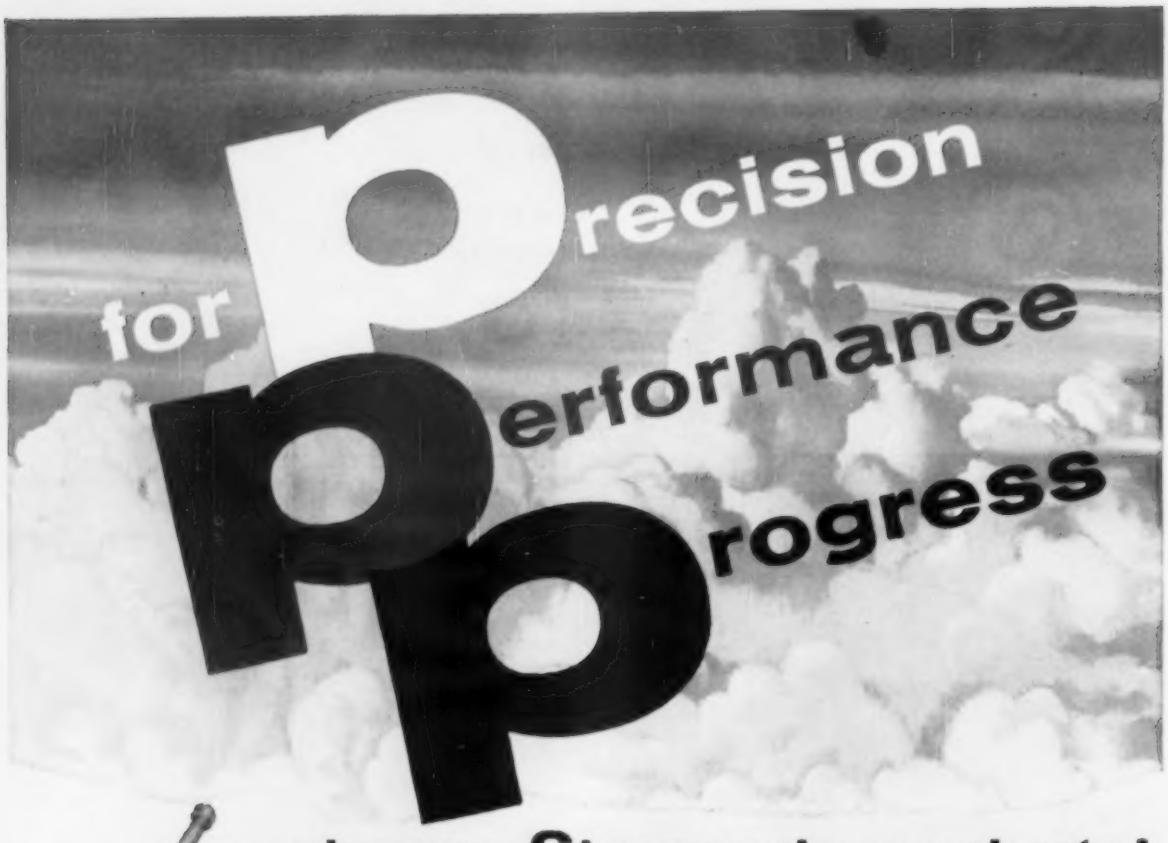
Eastern has solved many such problems in hydraulics . . . and in pressurization and electronic tube cooling units too. Inquiries are welcome regarding custom-made equipment to meet your requirements to government specifications.

Write for Aircraft Catalog

Eastern

INDUSTRIES, INC
100 SKIFF STREET
HAMDEN 14, CONN.

Circle Number 13 on Reader-Service Card



...choose Simmonds products!

ELECTRONIC • HYDRAULIC • MECHANICAL

Lightweight Pacitron Fuel Gage Systems: Fuel measurement and management systems incorporating latest technological improvements. Consistent reliability and dynamic progress are typified by the Load Limit Control, Center of Gravity Control and new True Mass Fuel Gaging System. Specification of Pacitron in latest military and commercial aircraft emphasizes Simmonds' continued leadership.

Simmonds SU Fuel Injection Systems: The only advanced type fuel injection system now in production for medium h.p. gasoline engines, the SU System has been proven in field tests to give economies up to 25%. Eliminates icing problems, gives improved cold starts.

Precision Push-Pull Controls: Simmonds Push-Pull Controls are positive, precise and rugged. Capable of heavy loads and accurate operation under vibration, continuous cycling, temperature extremes, etc. Proved in millions of miles of service on aircraft engines, pressurized doors and specialized applications.

Cowling and Access Latches: Heavy duty flush fitting aircraft latches for installation on cowlings and access panels. Two-piece toggle type, available to fit a wide range of structural curvatures; for attachment of plastic radomes, etc.

Liquid Level Sensing Systems: Working independently of the fuel gage system, this thermistor sensing system indicates accurately the precise time at which fuel, oil or other liquid goes above or below any designed level. It also automatically stops or starts pumps or valves to transfer the liquid from one tank to another. The system is rugged, has no tubes or moving parts, is light and compact. Operates on military aircraft fuels and oils.

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Circle Number 14 on Reader-Service Card

How to choose magnetic tape recorders for data

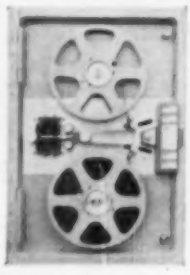
Types, performance and sources of further information

A magnetic tape recorder for your particular use is chosen from hundreds of possibilities, and yet from Ampex it can almost always be a standard production-line model. There are three reasons:

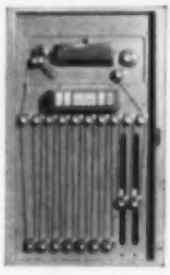
(1) Ampex offers the broadest available selection of basic types.

(2) Ampex modular design permits innumerable combinations of standard components to fit individual needs.

(3) By designing for the most critical user requirements, Ampex achieves performance standards ample for almost all practical uses.



Reel-to-reel



Continuous loop

TYPES OF TAPE TRANSPORTS

Reel-to-reel recorders are the most familiar. They record over relatively long time intervals, hence are almost always used for acquiring permanent data.

Continuous-loop recorders recycle on a definite time interval, either to provide a cyclic repetition of a length of data or to act as a time-delay device. The Ampex FL-100 is of this type.

Digital recorders, a special variation of reel-to-reel, are characterized by extremely rapid start-stop characteristics for close pulse packing. The Ampex FR-200 is typical.

"Transportable" recorders with varying degrees of portability are available from Ampex. Even Ampex's "fixed" recorders, FR-100 and FR-1100 may be mounted in a truck or trailer. But recorders like the Ampex 800 are built for true mobility, hence are light, compact and resistant to shock and vibration. Ampex also has miniaturized designs.

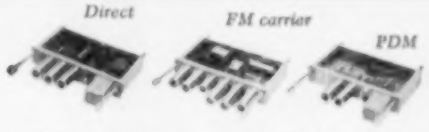
TYPES OF RECORDING

Most Ampex models use interchangeable plug-in amplifiers that enable each track to be used with any of three recording techniques:

Direct recording has frequency response of 100 to 100,000 cycles/sec. at 60 in/sec. tape speed. This high response is its greatest advantage and is utilized either directly or for multiplexed data.

FM-carrier recording has high instantaneous amplitude accuracy with frequency response of 0 (DC) to 20,000 cycles at 60 in/sec. It is used for transients, low frequencies and wherever accurate reproduction of amplitude is important.

PDM recording (pulse-duration modulation) can time-multiplex as many as 85 channels of data onto each tape track (data from 0 (DC) to a few cycles per second). PDM provides high accuracy and easy convertibility to digital form.



Plug-in amplifiers permit each tape track to be used with one of three recording techniques.

OTHER CONSIDERATIONS

Tape widths of quarter, half and one-inch width with 2, 3, 4, 7 and 14 parallel tracks are Ampex standards.

Commonly furnished tape speeds are 60, 30, 15, 7½, 3¾ and 1⅞ in/sec. Others are available. Recorders have up to eight speeds.

Time-base accuracy within 2 parts in 100,000 can be provided with standard Ampex accessory equipment.

Compatibility (for tape interchange) between Ampex recorders of same or different models is an important Ampex advantage.

Full performance specifications are available in literature on individual series.

A general application brochure and literature on individual models are available upon request. Ampex's Field Sales Engineers will be pleased to answer your inquiry with specific information on any requirement.

Write Dept. UU-1957

INSTRUMENTATION DIVISION
AMPEX CORPORATION

FIRST IN MAGNETIC TAPE INSTRUMENTATION

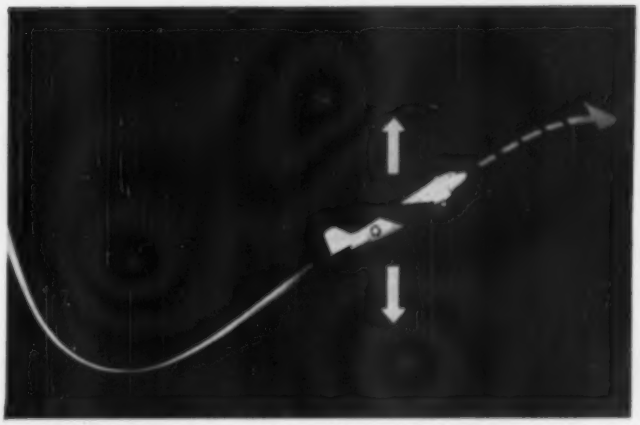
934 Charter Street • Redwood City, California

District offices serving all areas of the United States and Canada; Foreign Representatives in countries around the world.

Circle Number 15 on Reader-Service Card

Weightlessness — *What it is and what Douglas is doing about it*

When man invades outer space where neither normal gravity nor atmosphere exist, strange things will occur. Automatic functions—swallowing or even breathing—will demand the space traveller's deliberate thought. Exhaled carbon dioxide may smother him. Liquids won't flow, and undiffused sunlight will bathe him in a searchlight glare as micro-meteorites streak past at 50 miles per second. Such problems in the physiology and psychology of space travel have been an active concern at Douglas, ever since this Company's engineers—in 1946—first designed an earth satellite for the military.



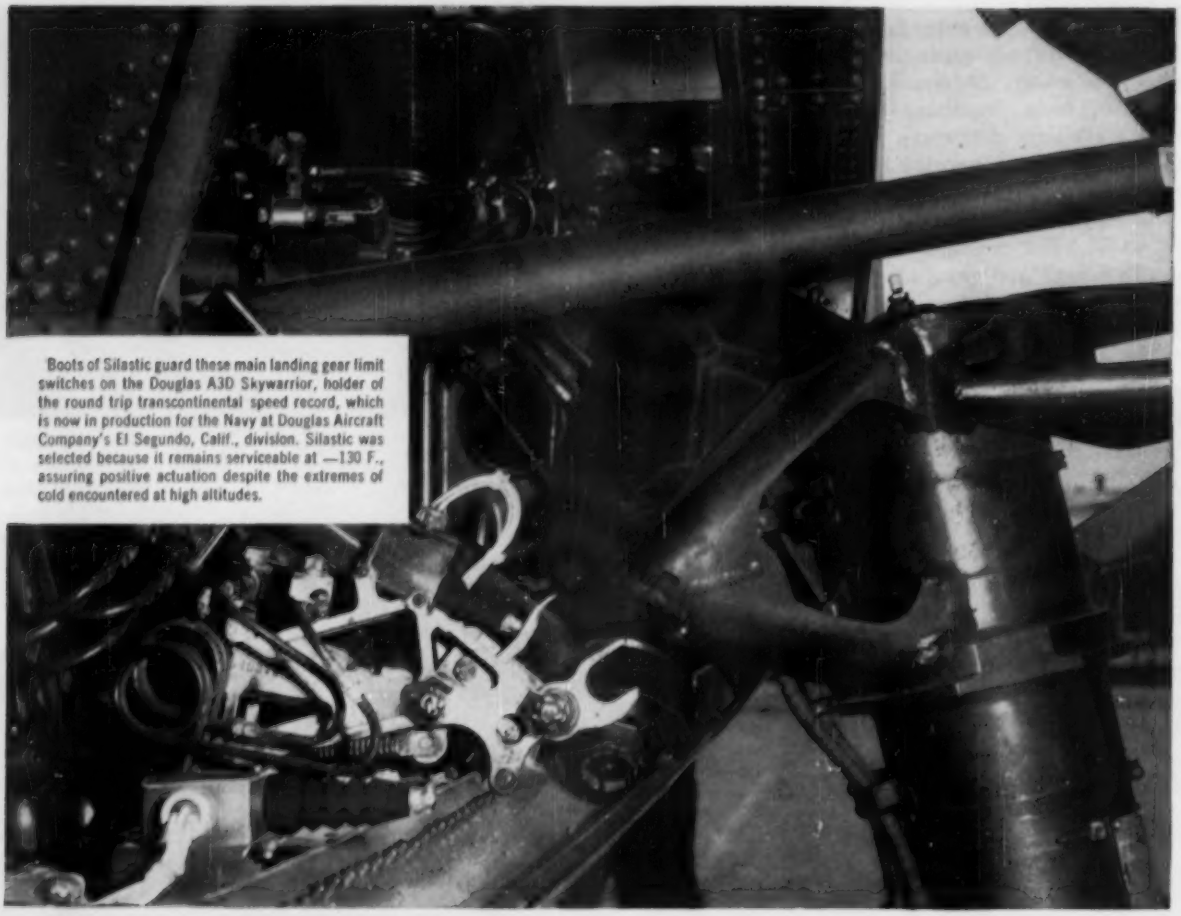
To study the problem of life without weight, Douglas engineers early proposed flying a curve in which the pilot was so balanced between gravity, centrifugal force, and drag that he could experience a *weightless* state. The USAF has conducted such experiments in a Douglas C-47. The record for a pilot is now 47 seconds, although weightlessness has been survived by animals for many minutes.

Forerunner of a practical space suit is the Navy's T-1 high altitude suit, designed by Douglas engineers for test pilots who undergo forces where a 200-pound man weighs more than half a ton and at altitudes where his blood would boil. The T-1 which has undergone pressure chamber tests equal to an altitude of 20 miles up, is only one of the projects completed at Douglas to speed the day when man will travel through space.

Depend on

DOUGLAS

first in Aviation



Boots of Silastic guard these main landing gear limit switches on the Douglas A3D Skywarrior, holder of the round trip transcontinental speed record, which is now in production for the Navy at Douglas Aircraft Company's El Segundo, Calif., division. Silastic was selected because it remains serviceable at —130 F., assuring positive actuation despite the extremes of cold encountered at high altitudes.

SILASTIC remains resilient down to –130 F

SILICONE RUBBER

Parts molded of Silastic*, the Dow Corning silicone rubber, retain their shape and flexibility over a 630 degree temperature span. And Silastic parts remain reliable in spite of weathering, ozone, and corona, and have very low compression set. All leading rubber companies now supply moldings, sponges, or extrusions of Silastic. A variety of shapes, colors and physical properties, including fuel and solvent resistance, are available.

Get latest data on Silastic

Mail coupon today

Dow Corning Corporation, Dept. 0918
Midland, Michigan

Please send me latest data on Silastic

NAME _____

COMPANY _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

*T M REG U S PAT OFF

Typical Properties of Silastic for Molded Parts

• Temperature Range, °F	—130 to 500
• Tensile strength, psi	600 to 900
• Elongation, %	150 to 300
• Compression set, %, @ 300 F	15 to 40
• Hardness range, durometer	20 to 90
• Dielectric strength, volts/mil	400 to 500
• Oil resistance	Dependent on type of oil

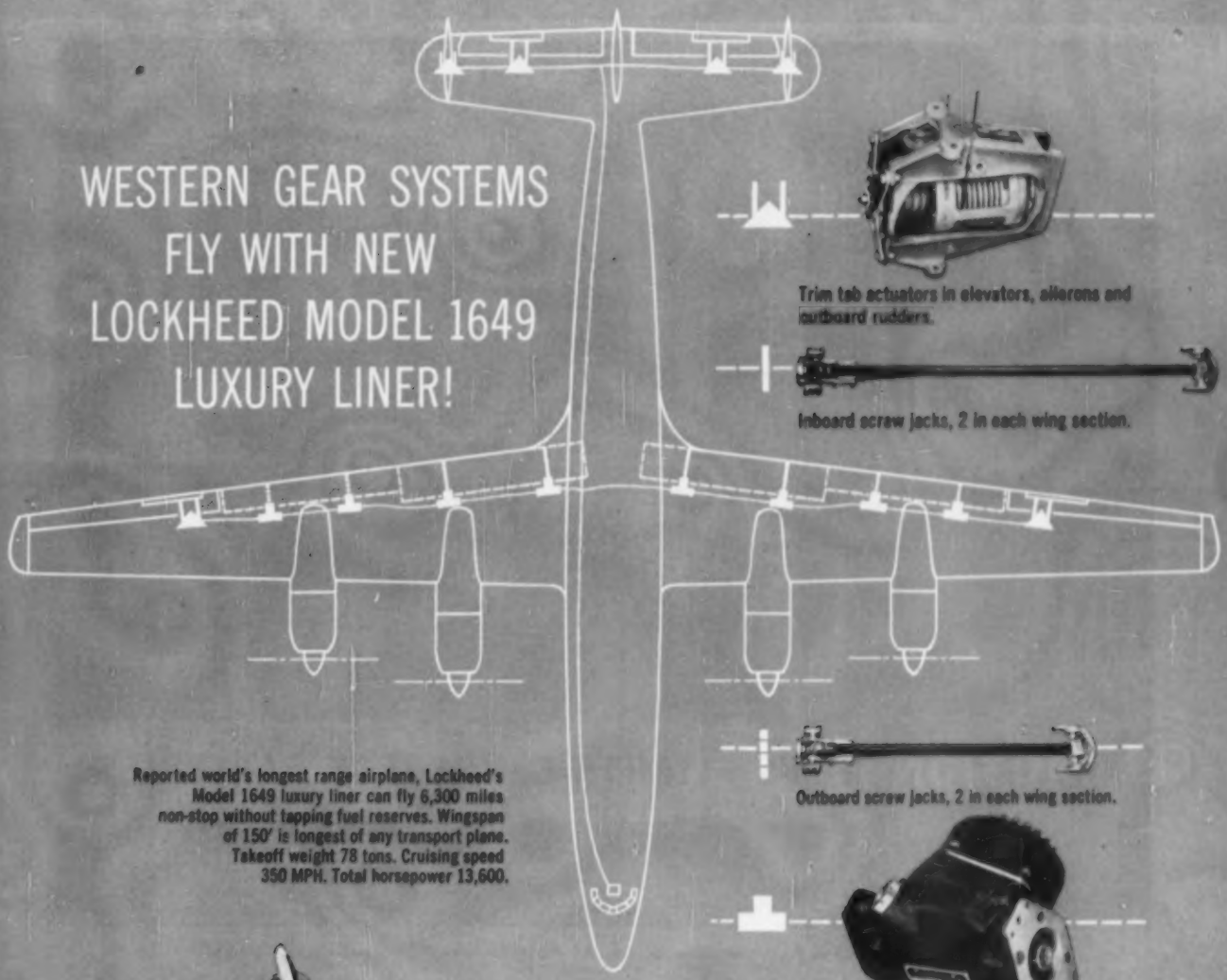
If you consider ALL the properties of a silicone rubber, you'll specify SILASTIC.

first in silicones — DOW CORNING SILICONES

DOW CORNING CORPORATION • MIDLAND, MICHIGAN

Circle Number 17 on Reader-Service Card

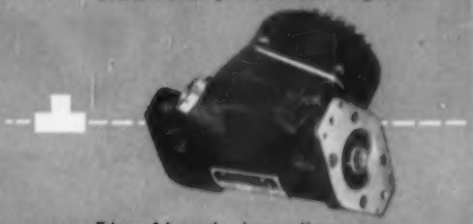
WESTERN GEAR SYSTEMS FLY WITH NEW LOCKHEED MODEL 1649 LUXURY LINER!



Trim tab actuators in elevators, ailerons and outboard rudders.

Inboard screw jacks, 2 in each wing section.

Outboard screw jacks, 2 in each wing section.



T-box, 4 in each wing section.

Reported world's longest range airplane, Lockheed's Model 1649 luxury liner can fly 6,300 miles non-stop without tapping fuel reserves. Wingspan of 150′ is longest of any transport plane. Takeoff weight 78 tons. Cruising speed 350 MPH. Total horsepower 13,600.

Western Gear's wing flap system on Lockheed's newest and largest luxury liner, Model 1649, using ball screws to actuate 335 sq. ft. of wing flap area, helps in takeoff and landing. Western Gear trim tab controls on both outboard rudders, elevators and ailerons aid in maintaining steady, true flight.

Assignment to design and construct such important control systems is evidence of Lockheed faith in Western Gear. Western Gear equipment is aboard virtually every major aircraft flying today, both commercial and military. Take advantage of 40 years of service to the aviation industry. Call on a Western Gear aircraft specialist for recommendations. Address General Offices, Western Gear, P.O. Box 182, Lynwood, California.

"The difference is reliability" • Since 1888

1649

WESTERN GEAR Corporation

ENGINEERS AND MANUFACTURERS

PLANTS AT LYNWOOD, PASADENA, BELMONT, SAN FRANCISCO (CALIF.) SEATTLE AND HOUSTON—REPRESENTATIVES IN PRINCIPAL CITIES

Circle Number 18 on Reader-Service Card

IN THE AIR AND SAFE. But how about the next takeoff? Will sudden battery failure mean a costly delay?

New Exide Aircraft Batteries far safer against long flight damage

Which battery grid would you rather put your trust in?

Silvium alloy grid after corrosion test.

Non-Silvium alloy grid after same test.

The worst risk an aircraft battery can face is the repeated overcharging it may be subjected to on long flights. Because then agents of corrosion quietly attack the positive plate grids.

But in the new Exide Aircraft Batteries for commercial planes, grids are made of Exide's exclusive Silvium* alloy—so corrosion resistant it actually prolongs grid life far beyond average battery life. Thus you are protected against the dangers of sudden battery failure and loss of electrical power just when you might need it most.

Why not benefit from this protection. It assures constant response to demands of heavy electrical loads as well as longer battery life. For complete information on Exide Aircraft Batteries, call your nearby Exide sales office. Or write Exide Industrial Division, The Electric Storage Battery Company, Philadelphia 2, Pa.

*U.S. patent

Exide®

Circle Number 19 on Reader-Service Card

The first Pantobase BLC transport

The usefulness of military transport aircraft has been extensively increased with the introduction of the Stroukoff C-134. Produced for the United States Air Force this rugged heavyweight requires extremely short take-off and landing runs and can operate from any surface—land, sand, ice, water, etc. Advanced airframe design has been combined with Stroukoff Pantobase and Boundary Layer Control Systems to produce a new type of aircraft equipped for a variety of assault and logistic missions requiring operation without the limitation of conventional runways.

The Stroukoff C-134 is destined for an important role in modern military strategy.

Interesting opportunities for qualified engineers in many fields exist at Stroukoff.

Extending the Frontiers of Aircraft Performance

Stroukoff AIRCRAFT CORP.

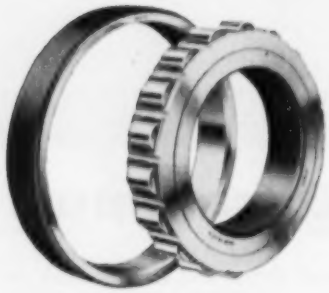
WEST TRENTON, N. J.

Circle Number 20 on Reader-Service Card

WHO is your best bet for jet engine roller bearings?

HYATT of course!

WHY?



Another GM contribution to aviation progress

1 YOU'LL FIND THE NAME HYATT on more jet engine roller bearings than any other name. As America's largest producer, we've amassed far more experience than any other supplier!

2 YOU'LL FIND THE NAME HYATT means cooperation—we work hand in hand with aircraft engineers, developing new bearings and applications—breaking old "bearing barriers"!

3 YOU'LL FIND THE NAME HYATT will protect your production schedules. We've got the tooling and the quality-control systems that enable us to produce the *highest quality, in quantity, on time!*

To break "bearing barriers" in a hurry, call HYATT for help! **For size ranges and load ratings of HYATT Aircraft Bearings, request Catalog A-56 from Hyatt Bearings Division, General Motors Corp., Harrison, N. J.**

HYATT HY-ROLL BEARINGS FOR AIRCRAFT INDUSTRY

Circle Number 21 on Reader-Service Card

AEROTEC

engineers in instruments and controls for *AIRCRAFT*

On practically every military and commercial plane specialized aircraft instruments and controls by Aerotec become the pilot's helping hand.

All of these instruments are specifically designed for a particular application. Some are fore-runners of future requirements in the conquest of space.

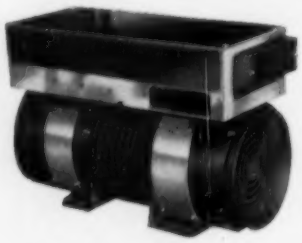
Aerotec can satisfy the unique requirements of aircraft manufacturers. When you have an instrumentation problem, call The Thermix Corporation.

AEROTEC

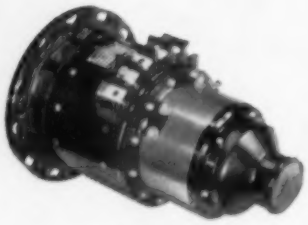
Project Engineers **THE THERMIX CORPORATION** Greenwich, Conn.
(Offices in all principal aircraft centers)
Canadian Affiliates: T. C. CHOWN, LTD., Montreal, Quebec

THE AEROTEC CORPORATION
Aircraft Division Greenwich, Conn.

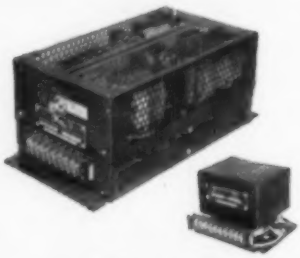
Circle Number 22 on Reader-Service Card



High-altitude and Missile INVERTERS

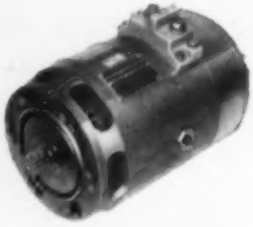


High-temperature AC GENERATORS

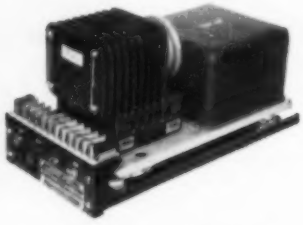


AC Voltage Regulators (Magnetic Amplifier Type) and SYSTEM COMPONENTS

Special-purpose Tubes featuring HARD GLASS TYPES



High-temperature DC GENERATORS



DC VOLTAGE REGULATORS and CONTROL PANELS

BENDIX RED BANK—UNEXCELLED PERFORMANCE

AROUND THE AROUND THE

There's no questioning the quality of special-purpose electron tubes or electrical power equipment when it's made by Bendix Red Bank. The proof is in acceptance—almost universal acceptance. Twenty-four hours a day, in countries around the world, equipment like that shown above is proving that skillful design and expert engineering (plus an almost unmatched quality control system) can build an international reputation for dependable performance. If you can use quality like this, call on us for recommendations. Write today for brochure detailing our engineering, production, and service facilities. RED BANK DIVISION, BENDIX AVIATION CORPORATION, EATONTOWN, NEW JERSEY.

West Coast Sales and Service: 117 E. Providencia Ave., Burbank, Calif.
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Red Bank Division

Bendix AVIATION CORPORATION

Circle Number 23 on Reader-Service Card

This is the first of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

What is an Alloy Steel?

Here is an easy definition to remember: An alloy steel is a grade of steel in which one or more alloying elements have been blended to give it special properties that cannot be obtained in carbon steel.

Or, here is the metallurgical definition: An alloy steel is one in which the maximum specified content of alloying elements exceeds one or more of the following limits—

Manganese, 1.65 pct; Silicon, 0.60 pct; Copper 0.60 pct

or in which a definite range or a definite minimum quantity of any of the following elements is specified or required within the limits of the recognized commercial field of alloy steels: aluminum, boron, chromium up to 3.99 pct, cobalt, columbium, molybdenum, nickel, titanium, tungsten, vanadium, zirconium, or any other element added to obtain a desired alloying effect.

As a rule, alloy steel is more difficult to make than carbon steel. There are more elements to be kept within specified ranges and, in general, the ranges of the alloying elements are comparatively narrow; hence the mathematical chances for producing off-heats are correspondingly increased. Moreover, most alloy steels require special reheating and cooling to prevent such imperfections as flaking and cracking.

Surface imperfections must be removed from the billets by scarfing, chipping, or grinding. More exacting methods of testing and inspection are necessary to insure uniformity.

WHERE DOES IT PAY TO USE ALLOY STEEL?

Generally speaking, it is advisable to use alloy steel when more strength, ductility, and toughness are required than can be obtained in carbon steel in the section under consideration. Alloy grades should also be used where specific properties such as corrosion-resistance, heat-resistance, and special low-temperature impact values are needed.

In some cases it requires considerable study to determine when and how to use a particular alloy steel to advantage in a product. Where there is any problem or doubt concerning its use, Bethlehem metallurgists will gladly give impartial advice on analysis, heat-treatment, machinability, and expected results.

In addition to manufacturing all AISI standard alloy steels, this company produces other than standard analysis steels and the full range of carbon grades.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

advance design

high temperature reinforced plastic ducting

Service Temperature for Silicone Resin and Fiberglass Laminates. Operating Temp: −320° thru +990°F. Short Exposure: −320° thru +2000°F. Stability Temp. of Materials −320°F. thru +600°F.

LOOK TO ARROWHEAD for advanced design—new ideas, new materials, new techniques—like this new fiberglass-silicon resin Starter Duct Support in the B-58 Supersonic Bomber. With a weight-strength ratio many times greater than steel, this high temperature resin part offers the ultimate in serviceability at extreme high and low temperatures.

Arrowhead Research and Development facilities are available to help you solve your ducting problems. Only Arrowhead has the experience, the ability and the facilities to answer *all* the problems, because only Arrowhead produces all three basic types of aircraft ducting—stainless steel, rigid plastic and flexible fabric-rubber.

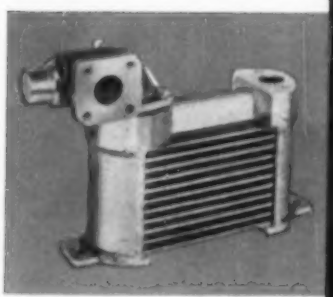
Write for service or consultation on *advance design* projects. Arrowhead field engineers are located in all aircraft centers.

ARROWHEAD PRODUCTS | Division of Federal-Mogul-Bower Bearings, Inc.

2300 Curry Street, Long Beach, California

Circle Number 24 on Reader-Service Card

FLYIN' FUEL...
ALWAYS COOL!



Flying Filling Station Features Harrison Coolers!

Fill 'er up . . . *way up!* Boeing's KC-97 handles the refueling job high in the sky. And it's Harrison that handles the heat on this flying gas tank. Harrison heat exchangers are designed to save weight and space . . . enable modern transport planes to carry bigger payloads and *carry them cooler!* That's why you'll find Harrison coolers on every type of aircraft . . . from the smallest personal planes to the biggest intercontinental bombers. If you have a cooling problem, you can be sure that Harrison has the answer!

HARRISON RADIATOR DIVISION, GENERAL MOTORS CORP., LOCKPORT, N.Y.

GM GENERAL MOTORS

TEMPERATURES MADE TO ORDER

HARRISON

Circle Number 25 on Reader-Service Card

project
VANGUARD
poses a
problem . . .
provide a
CONTINUOUS SOLUTION
to this time integral . . .
. . . and REEVES come up with the solution
Placing the earth's satellite in its pre-determined orbit requires precision
to the nth degree. The second-stage of the three-stage rocket
which will carry the satellite up to its orbit must be separated shortly before
its trajectory bends back towards the earth.
Separation of the second stage is controlled by a coasting time computer designed
and built for the Martin Company of Baltimore by Air Associates, Incorporated.
The Reeves Instrument Corporation has designed and is building for Air Associates
the "speedometer" needed for computing the second-stage coasting time
as a function of the burn-out speed. Essentially an integrating accelerometer,
it provides a continuous record of velocity as the rocket speed builds up
and feeds this information into the control unit's computer.
The control unit, after the computed coasting time has elapsed, triggers
the system. Stage two is separated and stage three gives the satellite the final
acceleration required for insuring that the satellite circles around the earth.
Because of its vast experience in design of precision gyros and accelerometers,
Reeves has been assigned the task of developing an important instrument
for use in one of man's great ventures, Project VANGUARD.
17RV5EA
Reeves
INSTRUMENT CORPORATION

REEVES INSTRUMENT CORP. *A SUBSIDIARY OF DYNAMICS CORP. OF AMERICA,* 215 EAST 91st ST., NEW YORK 28, N. Y.

Circle Number 26 on Reader-Service Card

an important OPEN LETTER concerning Your Aircraft Stainless Requirements

To all manufacturers of aircraft and component parts:

A recent survey revealed the fact that more stainless for aircraft is bought through warehouses than through the mill. This was no surprise to us, since U. S. Steel Supply has long been a major source of supply for your industry. Here are some of the advantages we offer you:

1. U. S. Steel Supply can ship many of your stainless requirements from stock. All other requirements, if the quantity is acceptable to the mill, can be produced to your order.

2. Our districts are prepared to service your inquiries and orders intelligently and promptly.

3. Our inventory is ordered to our own specifications which are tailored to meet the requirements of many of the aircraft specifications. In all cases the orders accepted for stainless steel can be certified to the applicable aircraft specifications.

4. In addition, our Newark, Los Angeles, St. Louis and Dallas warehouses maintain large inventories of Type 301 sheets, annealed ¼, ½, ¾ and full hard produced to MILS 5059A; Type 321 and 347 sheets produced to MILS 6721; Type 321 rounds and hexagons produced to QQ-S-00763A.

5. If you require assistance, our stainless representative or metallurgist is ready to draw upon his wealth of experience to help you. If he does not know the answer, he knows where to get it for you.

Many of the nation's leading aircraft manufacturers and aircraft component parts manufacturers are regularly using our services. If you are not one of them, please call us. We will welcome an opportunity to be of service to you.

SEND FOR YOUR COPY TODAY!

NEW BOOKLET AVAILABLE ON AIRCRAFT STEELS OF TOMORROW

Have you been wondering what is being done in the development of aircraft steels to meet the challenge of supersonic flight? A recently published United States Steel pamphlet, "Special Steels for the Aircraft of Tomorrow," will bring you up-to-date on what U. S. Steel has been doing in its research and development program for your industry.

U. S. Steel Supply Division, Dept. T-67
208 S. LaSalle Street
Chicago 4, Illinois

Please send me without charge the booklet, "Special Steels for the Aircraft of Tomorrow."

Name .....
Company .....
Address .....
City ..... State .....

U. S. STEEL SUPPLY
DIVISION

P. O. Box 1099, Chicago 90, Ill. — *General Offices:* 208 S. LaSalle Street, Chicago 4, Ill.

Warehouses and Sales Offices Coast to Coast

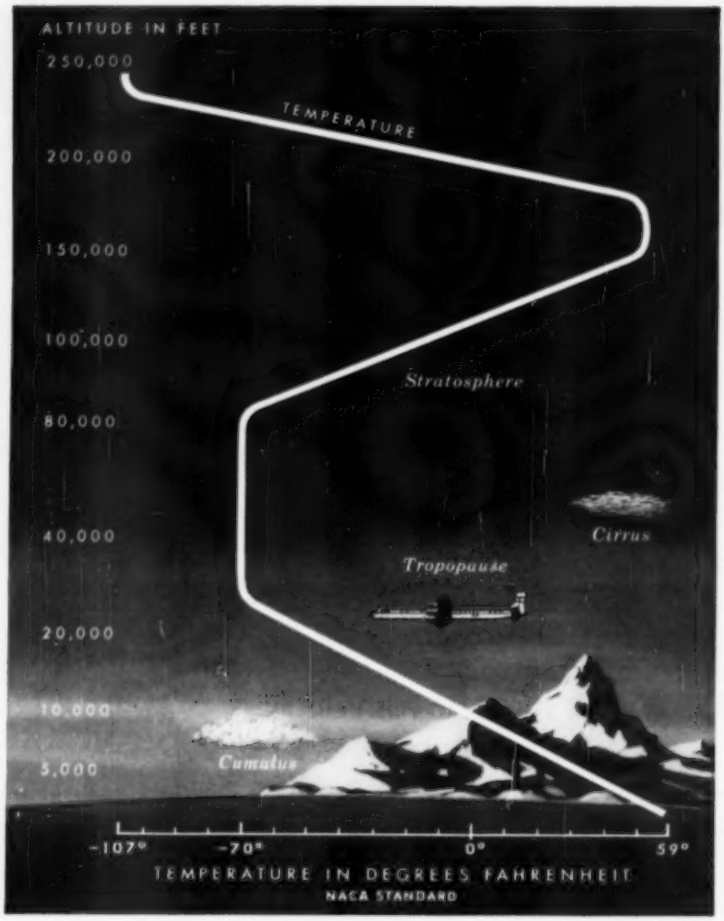
UNITED STATES STEEL

FLY WEATHER-WISE — Mobil

These weather items prepared in consultation with the United States Weather Bureau

TEMPERATURE VARIATIONS

IN RELATION TO ALTITUDE...



TEMPERATURES encountered in a single flight may vary as much as 130°F. or more. These variations are associated with altitude and weather patterns and can affect flight performance.

Temperature and altitude—Heat from the earth warms the atmosphere with steadily decreasing effect as altitude increases. Temperature normally decreases with altitude at the rate of 3½°F. per 1000 ft. At the tropopause (top of troposphere) temperature remains almost constant up to 80,000 ft. Therefore, modern aircraft encounter coldest air in the tropopause layer which varies from about 28,000 ft. in the polar air masses to 54,000 ft. in the tropical.

As altitude increases from approximately 80,000 ft. to 150,000 ft., the temperature returns to almost sea level condition. This is the result of strong absorption of the sun's ultra-violet rays in the layer of ozone gas at very high altitudes.

At still higher altitudes, the temperature reverts to extreme cold.

FORECAST: *Top Flight Performance with Mobil Aero Hydraulic Oils and Mobilgrease Aero!*

Mobil

Leader in lubrication for 91 years

Instant control response can be yours despite extreme temperature variations, thanks to the wide range of temperature characteristics of these top-quality Mobil products.

Mobil Aero Hydraulic Oil HF and HFA—These low pour point and high VI oils help assure trouble-free operation of hydraulic control systems, brakes and struts through all temperature ranges.

Mobilgrease Aero Lo-Temp and General Purpose—These Aero greases help assure smooth operation of all sliding and rolling surfaces of aircraft parts . . . control systems, bearings, and gears.

SOCONY MOBIL OIL COMPANY, INC., and Affiliates:
MAGNOLIA PETROLEUM COMPANY,
GENERAL PETROLEUM CORP., MOBIL OVERSEAS OIL CO., INC.

Circle Number 28 on Reader-Service Card

Motor - Gear - Trains

3:1 to 150,000:1 Ratio Range • Up to 18 Foot Pounds Torque

- Motors available: DC, 60 or 400 cycle, PM, split series, series, shunt, single phase and 2-phase. All are reversible.
- Available with either governor or brake.
- 1000 hour life minimum.
- Designed to meet MIL-E-5272A.
- Precision gearing throughout.
- Can be furnished up to 125°C.
- Designed for continuous duty or intermittent duty applications.

MOTOR GEAR TRAIN												
Gear Ratio	No-Load Speed	Nominal Voltage D.C.	Voltage Range D.C.	No-Load Current	Normal Speed	Normal Load OZ.IN.	Normal Current	Operating Temp. Range	Size	Overall Length Inches-Max.	Motor Type	Mounting	Oster Type
5.88:1	1800	28	24-32	0.4	1800	5.0	1.0	-55° To +85°C	13	3.777	P.M. GOVERNOR	FACE	13R-9102-08
17.9:1	600	28	24-32	0.4	600	12.0	1.0	-55° To +85°C	13	3.930	P.M. GOVERNOR	FACE	13R-9102-06
32.3:1	300	28	24-32	0.4	300	12.0	1.0	-55° To +85°C	13	3.935	P.M. GOVERNOR	FACE	13R-9102-03
67:1	150	28	24-32	0.4	150	12.0	0.6	-55° To +85°C	13	4.082	P.M. GOVERNOR	FACE	13R-9102-05
85:1	150	27.5	—	.25	130	50.0	0.7	-55° To +85°C	13	4.095	P.M.	FACE	13R-9101-11
109:1	100	28	24-32	0.4	100	32	0.6	-55° To +85°C	13	4.094	P.M. GOVERNOR	SYNCHRO	13R-9102-12
109:1	100	27.5	—	0.4	175	30	0.5	-55° To +180°C	13	2.843	P.M.	FLANGE	13R-9104-01
125:1	75-90	28	—	.25	70-85	20	0.3	-55° To +71°C	13	3.926	P.M.	FACE	13R-9101-13
157:1	60	28	24-32	0.4	60	12.0	0.6	-55° To +85°C	13	4.095	P.M. GOVERNOR	FACE	13R-9102-03
285:1	40	35	—	.25	40	100	0.6	-55° To +71°C	13	4.038	P.M.	FACE	13R-9103-01
333:1	30	28	24-32	0.4	30	12.0	0.6	-55° To +85°C	13	4.317	P.M. GOVERNOR	FACE	13R-9102-04
410:1	15	27	25-29	0.3	15	8.0	0.3	-55° To +85°C	13	4.400	P.M. GOVERNOR	FACE	13R-9102-11
1043.8:1	5-10	27	24-30	0.15	7	30	0.2	-55° To +71°C	13	4.458	P.M. BRAKE	FACE	13R-9105-01
1044:1	5-10	27	24-30	0.15	7	30	0.2	-55° To +71°C	13	3.910	P.M.	FACE	13R-9101-12
2214:1	3-4	6	—	1.2	3.4	30	1.2	-55° To +71°C	13	4.454	P.M.	FACE	13R-9101-04
3241:1	5.5	35	—	.35	5.5	18	0.4	-55° To +71°C	13	4.454	P.M.	FACE	13R-9101-02
5833:1	1.3	30	—	.13	1.3	30	0.15	-55° To +71°C	13	4.816	P.M.	FACE	13R-9101-10
21,787:1	2-3	120	—	.25	2-3	12	0.25	-55° To +71°C	13	3.475	P.M.	FLANGE	13R-9101-15
322:1	80	110	—	0.2	30	240	0.3	-55° To +71°C	15	3.815	SPLIT SERIES	FLANGE	15R-9201-01
467:1	22	27	—	0.2	20	8	0.2	-20° To +50°C	15	3.988	SPLIT SERIES	SYNCHRO	15R-9201-03
433:1	30	26	—	0.6	25	260	1.2	-50° To +80°C	15	3.110	SHUNT	FACE	15R-9201-02
955:1	33	27	—	0.6	12-18	420	1.0	-55° To +50° C	15	4.419	SPLIT SERIES	FLANGE	15R-9201-08
28:1	240	27.5	24-29	0.65	240	40	1.3	-10° To +71°C	17	5.315	SHUNT GOVERNOR	SYNCHRO	17R-9251-01
4.26:1	1800	28	—	0.6	1800	12	1.85	-30° To +95°C	24	4.640	SHUNT GOVERNOR	FACE	24R-9451-01

Speed tolerance on governed motors is ±2% over voltage and an ambient temperature range. Closer speed tolerance units can be designed to fit the particular application.

Many other variations available. There is an Oster motor-gear-train to fit your exact specification. Consult Oster specialists today, sending your detailed requirements.

Other products include servos, synchros, AC drive motors, DC motors, servo mechanism assemblies, synchro indicators, servo torque units, reference and tachometer generators, actuators, motor driven blower and fan assemblies and fast response resolvers.

John Oster MANUFACTURING COMPANY
Your Rotating Equipment Specialist
AVIONIC DIVISION
Racine, Wisconsin

Engineers For Advanced Projects:
Interesting, varied work on designing transistor circuits and servo mechanisms. Contact Mr. Zelazo, Director of Research, in confidence.

BURTON BROWNE ADVERTISING

Case History from the files of the Wincharger Corporation

problem: PREVENT CORONA FLASH-OVER IN DYNAMOTORS AT INFINITE ALTITUDES

At the end of World War II, Wincharger was providing aircraft manufacturers with dynamotors designed to operate at 30,000 feet. But as higher altitude jet aircraft were developed, this same dynamotor was facing altitudes up to 80,000 feet.

These infinite altitudes presented complex electronic problems. One of the more serious was Corona flash-over.

Wincharger's Research and Development Group tackled the problem. They found the solution in the Dynamotor's insulation. New methods and materials were used against Corona flash-over action. And the newly insulated Wincharger Dynamotor operated with dependable efficiency at stratosphere heights.

If special purpose Dynamotors and power supplies solve your problem, contact Wincharger. Their extensive experience in solving problems in all phases of these fields is your best assurance of a workable solution.

Dept. AW-67

WINCO®

Specifications

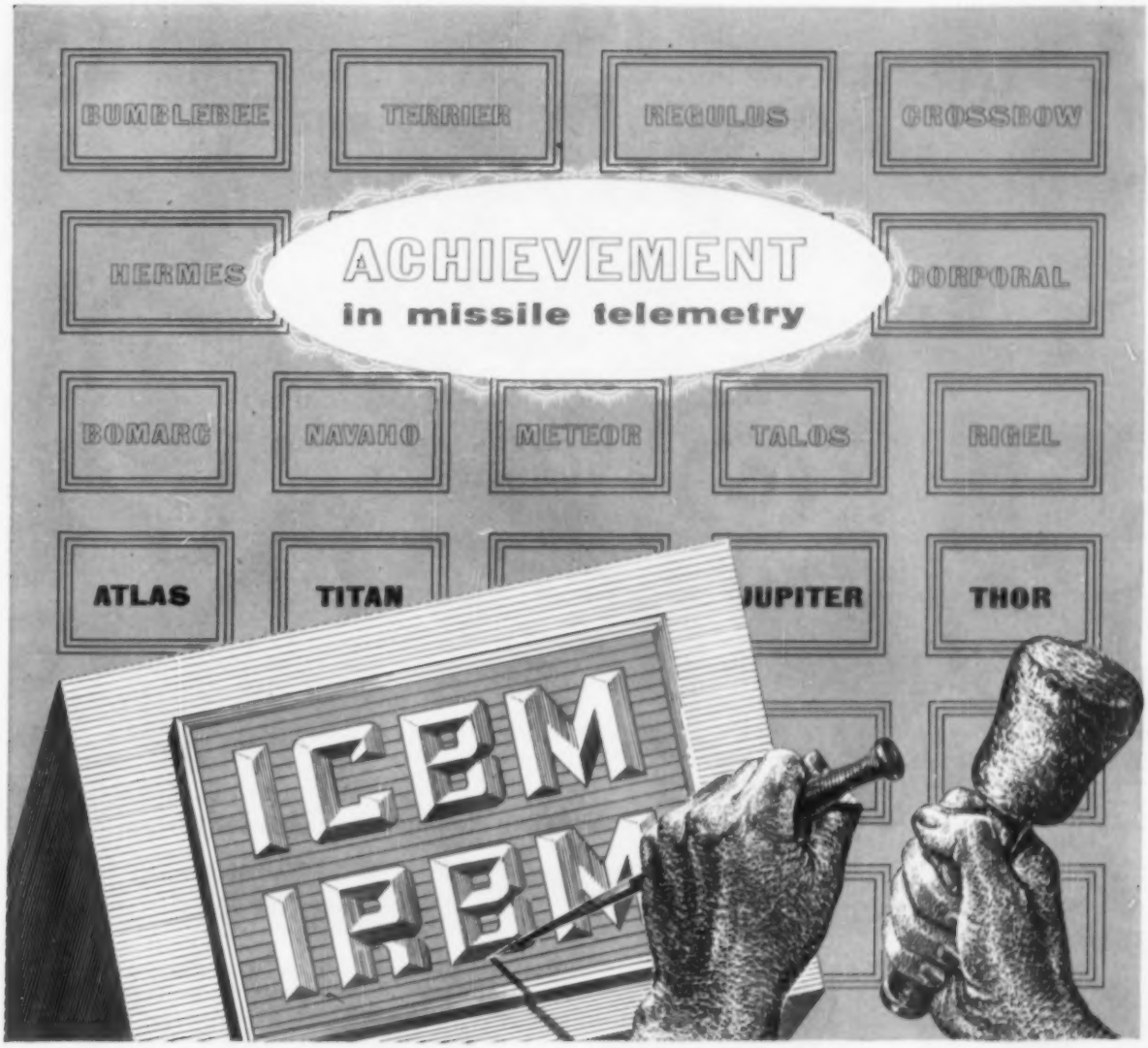
Input	Normal 27.5 Volts D.C.
Output No. 1	600 Volts D.C. at 550 Mils.
Output No. 2	250 Volts D.C. at 150 Mils.
Unfiltered Ripple Maximum	1%
Duty Cycle	5 minutes on, 5 minutes off, and repeat.
Ambient Temperature	Minus 55° C to plus 85° C.
R.P.M.	8,500
Altitude	80,000 feet.

WINCHARGER CORPORATION

SIOUX CITY, IOWA

Subsidiary of the Zenith Radio Corporation

Circle Number 30 on Reader-Service Card



From BUMBLEBEE to the new ballistics programs Bendix-Pacific has contributed a steady succession of telemetering achievements to America's missile development programs.

A true pioneer in missile instrumentation, Bendix-Pacific Components and Systems have been used by most major missile programs for the past eleven years. Now, with its latest assignment, Bendix-Pacific is proud to add the ICBM and IRBM missiles to the growing list of projects on which it has played an important part.

Bendix
PACIFIC DIVISION
Bendix Aviation Corporation
NORTH HOLLYWOOD, CALIF.

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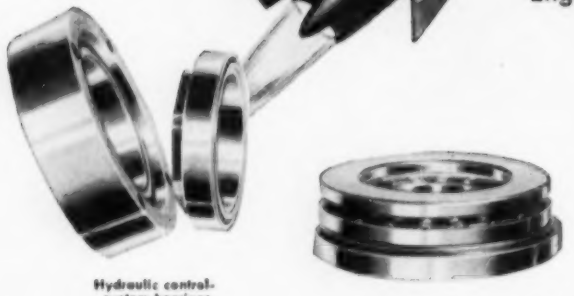
Increasingly higher speed and thermal characteristics...

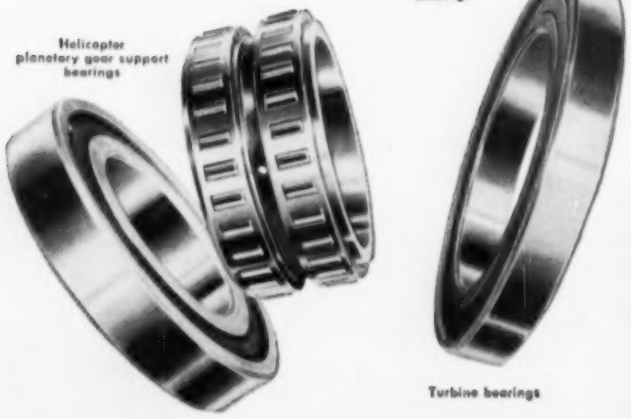
Engineering developments that make Rollway Cylindrical Roller Bearings suitable for a wide range of aircraft applications



Hydraulic control-system bearings

Helicopter rotor assembly thrust bearings

Helicopter planetary gear support bearings



Turbine bearings

Eight years after the Wright brothers' flights at Kittyhawk, Rollway began the production of cylindrical roller bearings. Careful inspection, metallographic checks, design evaluations and lubrication studies have steadily improved the range, speed, stress, ambient and operating temperatures.

We produce the practical, while we develop the science of the possible. Our key personnel are always ready to work on experimental or production models where high-stress, high-temperature, and high-precision bearings are essential.

Illustrated are a few of the Rollway Bearings produced for general aeronautics use. Not illustrated, for obvious reasons, are Rollway experimental bearings developed for test in various projects. A wire, letter or print will initiate a cooperative relationship that could be mutually rewarding. *Rollway Bearing Co., Inc., Syracuse, N. Y.*

ROLLWAY

BEARINGS

COMPLETE LINE OF RADIAL AND THRUST CYLINDRICAL ROLLER BEARINGS

ENGINEERING OFFICES: SYRACUSE • BOSTON • CHICAGO • DETROIT • TORONTO • PITTSBURGH • CLEVELAND • MILWAUKEE • SEATTLE • HOUSTON • PHILADELPHIA • LOS ANGELES • SAN FRANCISCO

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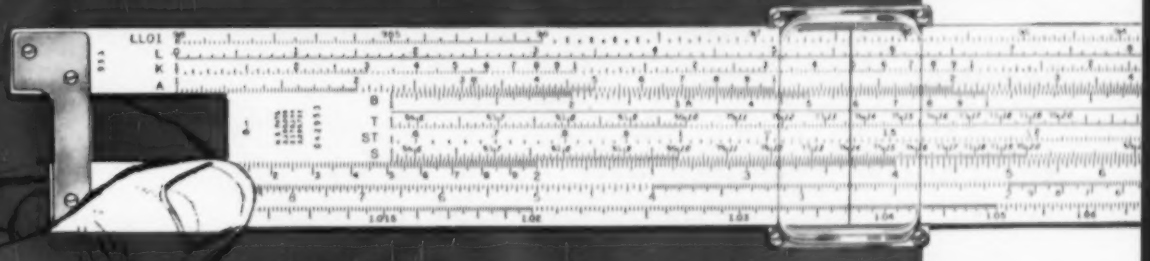
LOOKING FOR ENGINEERS?



Can you use the experience, knowledge, and skill of our seasoned and successful engineers *right now?*

They are available immediately to solve design, development and production problems involving power transmission, actuation or gearing for any and every phase of the aviation industry. And they're backed by a modern precision production plant—a plant capable of translating advanced concepts into precision components and assemblies on a *production* basis.

You can count on Foote Bros. engineering and facilities to come through with the answer and the *production* wherever and whenever you need it. It will pay you to ask Foote Bros. first.

this trademark stands for the finest industrial gearing made

FOOTE BROS.

Better Power Transmission Through Better Gears

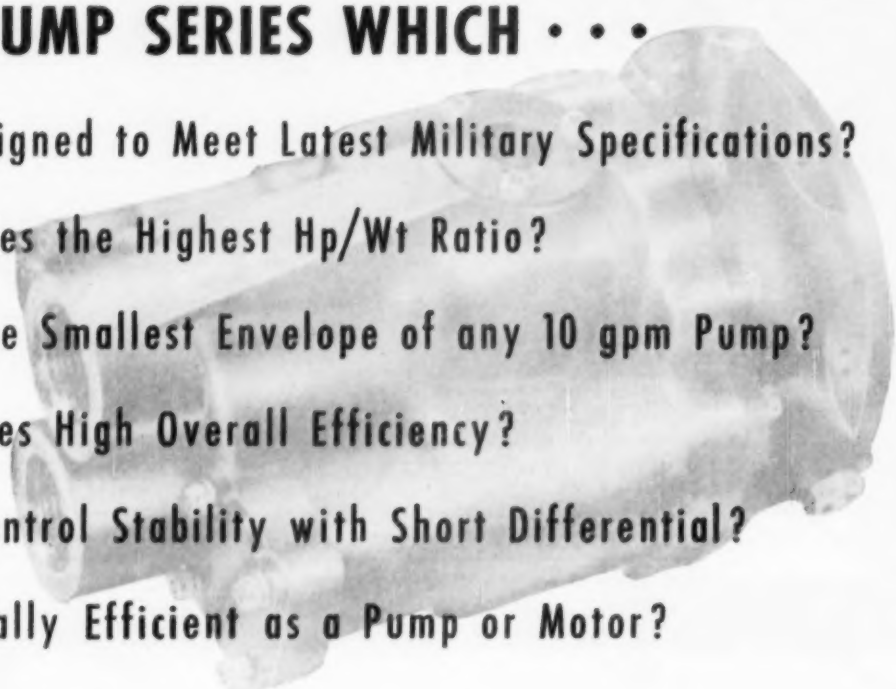
FOOTE BROS. GEAR AND MACHINE CORPORATION

4589 South Western Boulevard, Chicago 9, Illinois

Circle Number 33 on Reader-Service Card

is there

A NEW, LARGE CAPACITY 3000 PSI PUMP SERIES WHICH • • •



Is Designed to Meet Latest Military Specifications?

Provides the Highest Hp/Wt Ratio?

Has the Smallest Envelope of any 10 gpm Pump?

Features High Overall Efficiency?

Has Control Stability with Short Differential?

Is Equally Efficient as a Pump or Motor?

yes!

THE *STRATOPOWER*® OVER-CENTER PUMP

The New STRATOPOWER Over-Center Pump, now undergoing tests, is exhibiting performance characteristics that are exceeding expectations. This smooth-running, self-priming Pump with notably low pulsation and transient pressure characteristics, is the answer to many hydraulic problems for large aircraft systems. Progress reports on this important development will be sent to engineers interested in advanced hydraulic design.

WATERTOWN DIVISION
THE NEW YORK AIR BRAKE COMPANY
STARBUCK AVENUE • WATERTOWN • N.Y.

Circle Number 49 on Reader-Service Card

Which one of these Genisco centrifuges meets your requirements for testing components under simulated operational G-loadings?

...as required by Mil 5272A, procedure II

Genisco G-Accelerators provide a quick, precise means of testing components in an acceleration environment similar to that encountered in actual operation.

They are extremely accurate machines, easy to operate and built to withstand years of hard use.

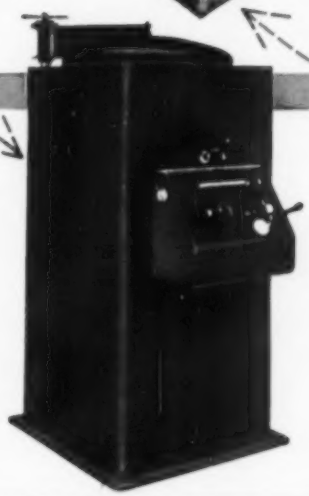
These features particularly suit them for large volume testing programs, as well as for precise laboratory prototype development.

More than 100 Genisco G-Accelerators of various capacities are now in use throughout the world.

Complete technical information on all models and accessories is available. Please direct your inquiry to: Contracts Manager, Genisco, Inc., 2233 Federal Avenue, Los Angeles 64, California.

MODEL C159 The larger capacity of this machine permits whole system components and complete packages to be tested. Two objects, each weighing 100 pounds and 24" x 24" x 18" in size, can be accommodated simultaneously. G-range of the machine is 0.024 G to 75 G's. Maximum centrifugal capacity is 2000 G-pounds. Nominal radius of gyration 48".

MODEL B78 Used primarily for testing relays, switches, tubes, motors, valves, and other small components, and to calibrate and evaluate accelerometers. Accommodates objects weighing up to 25 lbs.; has G-range of 0.017 G to 120 G's. Maximum centrifugal capacity is 1200 G-pounds. Nominal radius of gyration 24".



MODEL D184 A high-speed machine, designed to test accelerometers and other instruments under acceleration forces from 1 to 850 G's. Full centrifugal capacity is 1000 G-pounds. Nominal radius of gyration 12".

MODEL E185 This newest and largest Genisco centrifuge was recently built for the U.S. Air Force. Two mechanical or electronic packages, each weighing up to 300 pounds, can be subjected to an acceleration environment of up to 65 G's simultaneously. Nominal radius of gyration of the machine is six feet. An automatic dynamic balancing system automatically compensates for any excessive unbalance in the machine during test runs.

ACCESSORIES ADD TO OPERATING EASE A number of accessories including a strobe system, air system, optical system, tub cover, access doorway, and slip ring systems, designed to give greater operating convenience, are available for Genisco G-Accelerators, Models B78 and C159.

Modifications in any basic machine or accessories to meet your particular requirements will be carefully considered.

Genisco
INCORPORATED

RELIABILITY FIRST

Circle Number 48 on Reader-Service Card

Leading Aircraft Subcontractor Proves Job Shop Economy of Sciaky Counter Weld Control

Electronic Welding Company of Los Angeles, California, has now completed over eight months production experience with the new Sciaky Predetermined Electronic Counter Controlled Resistance Welder. Their experience proves that the advantages of the new Sciaky welder already proved in high production service apply equally to "job shop" requirements.

Ease of Set-Up Is a Key Factor

Mr. George Palmer, President of Electronic Welding Company, sums up his experience when he says, *"The new Sciaky welder control gives us a definite advantage over the R-C timer. We get unusual ease of developing and repeating weld schedules, including those requiring certification in accordance with Milspecs."*

Versatility is Vital for Job Shop Operations

The versatility of the Sciaky Predetermined Electronic Counter Controlled Welder makes it the logical answer to Electronic Welding Company's requirements. Simple set-up minimizes the need for hard-to-get skilled labor. Its suitability for aluminum, steel, stainless, jet engine alloys, brass, etc., makes practical the use of the machine on both aircraft and non-aircraft work.

At Electronic Welding Company, a single Sciaky spot welder is used for work on the J-57 program and for airframe structurals in the F-104 and B-52 programs. Current usage is two ten hour shifts per day.

Mr. Palmer states that *"having a Sciaky Predetermined Electronic Counter Controlled Welder is almost prerequisite to getting subcontracts from airframe and jet engine manufacturers and ordnance contractors as well as from commercial manufacturers who require the highest standards of weld safety and economy."*

To prove his confidence, Mr. Palmer has placed orders for two more of the new Sciaky Welders. One is a spot welder, the other a seam welder.

Production Advantages

Important to all who require safe, economical welds is the precise control provided by the new Sciaky Welder. Users report that they get *precisely* what they set on the welder. The machine cannot deviate from its setting and it is consistent throughout the entire range of adjustment.

Another advantage is the simplicity of maintenance. Plug-in sub-assembly control units make it possible to replace a unit in a matter of minutes. Further, the plug-in feature permits easy addition of additional functions if they are ever required.

Literature Available

Technical bulletins completely describing the new Sciaky Predetermined Electronic Counter Weld Control are available. Write on your company letterhead requesting Bulletins 338 and 339. There is no obligation.

ELECTRONIC WELDING COMPANY'S new Sciaky Counter Control Welder. It is shown here welding an afterburner door for the Pratt & Whitney J-57 jet engine. Note the in-production use of a Brush recording welding analyzer.

Largest Manufacturers of Resistance Welding Machines in the World

SCIAKY

Sciaky Bros., Inc., 4935 West 67th Street, Chicago 38, Ill., Portsmouth 7-5600

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THE MARK OF QUALITY

BARBER COLMAN

Aircraft Controls

BARBER-COLMAN TEMPERATURE CONTROL SYSTEMS

A proportioning polarized relay control system is applied to the B-58. The complete line of Barber-Colman temperature controls for aircraft includes: Cycling, proportioning, floating, electronic, transistor, magnetic amplifier, polarized relay.

CONTROL BOX

VALVE

SENSING UNIT

Barber-Colman temperature controls selected for B-58 detachable pod

America's first supersonic bomber, the USAF B-58 "Hustler" built by Convair, is designed specifically to carry a detachable "pod" under its fuselage. With these capsules, this versatile plane is capable of performing a wide variety of missions. To maintain a constant temperature in a pod flight test equipment compartment, Convair has chosen a Barber-Colman temperature control system. Other Barber-Colman equipment is furnished to contractors of the B-58 air conditioning system. For help on your control projects, consult the Barber-Colman engineering sales office nearest you: Los Angeles, Seattle, New York, Fort Worth, Baltimore, Montreal.

CAREER OPPORTUNITIES: Excellent openings for qualified engineers

BARBER-COLMAN COMPANY

Dept R, 1422 Rock Street, Rockford, Illinois

Aircraft Controls • Electrical Components • Automatic Controls • Industrial Instruments • Air Distribution Products
Small Motors • Overdoors and Operators • Molded Products • Metal Cutting Tools • Machine Tools • Textile Machinery

Uniformity in handling and service performance

Aircraft Cable ★ Terminals ★ Assemblies

by MACWHYTE

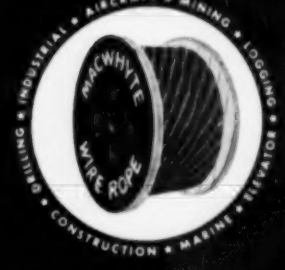
Uniformity in handling—uniformity in service are attained through rigid quality control and precision manufacturing. That's your assurance when you use Macwhyte "Hi-Fatigue" Aircraft Control Cable, Terminals, and Assemblies.

There's a complete line of sizes and types of Macwhyte Aircraft Control Cable in Galvanized, Tinned, and Stainless Steel. Properly PREformed, "Hi-Fatigue" cable lies dead with no tendency to unlay, twist, or curl. Assemblies can be made to closer tolerances, because there is minimum uniform stretch in any length of cable.

Macwhyte "Safe-Lock" Stainless Steel Terminals for swaging are manufactured to exceed the requirements of Military Specifications.

Macwhyte Aircraft Cable is available in reel lots or cut to length. Terminals are sold loose or attached to cable. Assemblies are made to order.

Ask for Macwhyte Aircraft Catalog A-3.



MACWHYTE COMPANY
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Manufacturers of "Hi-Fatigue" Aircraft Cable—"Safe Lock" Cable Terminals—Cable Assemblies—Tie Rods—Braided Wire Rope Slings—Bright, Galvanized, Stainless Steel, and Monel Metal and Plastic Coated Wire Rope.

Mill Depots: **New York 4,** 35 Water St. • **Pittsburgh 36,** 353 Curry Hollow Road • **Detroit 3,** 75 Oakman Blvd. • **Chicago 6,** 228 S. Desplaines St. **St. Paul 14,** 2356 Hampden Ave. • **Fort Worth 1,** P. O. Box 605 • **Portland 9,** 1603 N.W. 14th Ave. • **Seattle 4,** 87 Holgate St. • **San Francisco 7,** 188 King St. • **Los Angeles 21,** 2035 Sacramento.

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WHICH of these Actuation Problems are YOURS?

☐ POWER CONSUMPTION ☐ SPACE/WEIGHT ☐ PRECISION

☐ TEMPERATURE ☐ LUBRICATION ☐ DEPENDABILITY

SAGINAW b/b SCREWS will help you solve them!

ORIGINAL DESIGNERS AND PRODUCERS OF MULTIPLE CIRCUITS

If one circuit should fail, the rest will function without interruption, sharing the load between them. In critical applications this feature has no equal.

6 BASIC DESIGN ADVANTAGES

1. Vital Power Savings. Permit much smaller motors with far less drain on electrical system, simpler circuitry.

2. Space/Weight Savings. Screws themselves are smaller, lighter; permit smaller motors and gear boxes; eliminate auxiliary equipment required by hydraulics.

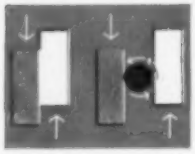
3. Precise Positioning. Machine-ground type will position components far more precisely than hydraulics or pneumatics; tolerances on position are held within .0006 in./ft. of travel.

4. Temperature Tolerance. Normal operating range from −75° to +275° F.; in selected materials, will function efficiently at temperatures as high as +900° F.

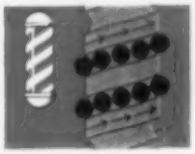
5. Lubrication Latitude. If lube fails, will still function with remarkable efficiency. Units have been built and qualified for operation without lubrication.

6. Fail-Safe Performance. Far less vulnerable than hydraulics; Gothic-arch grooves, yoke deflectors and multiple circuits provide added assurance against failure.

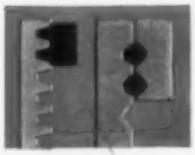
Here's why they're 90% efficient, save 4/5 on torque:



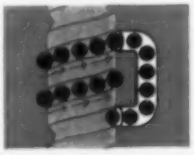
Let's start at the beginning, with the familiar principle that there's far less friction in *rolling* than in *sliding*. By applying this principle,



Like stripes on a barber pole, the balls travel toward end of nut through spiral "tunnel" formed by concave threads in both screw and mating nut.



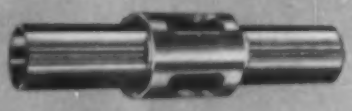
the *Saginaw ball/bearing Screw* radically increases the efficiency of rotary-to-linear motion (and vice versa). Instead of *sliding*, mating surfaces *glide* on rolling steel balls.



At end of trip, one or more tubular guides lead balls diagonally back across outside of nut to starting point, forming closed circuit through which balls recirculate.

Available in custom machine-ground and stock rolled-thread types. Units have been built from 1½ inches to 39½ feet long—⅜ to 10 inches in diameter.

SAGINAW b/b SPLINE



This revolutionary new kind of spline utilizes the same basic principle pioneered by Saginaw in the ball bearing screw.

It permits new engineering designs never before practical—literally lets you achieve the "impossible"! In any application where column length must change under torque load, the Saginaw b/b Spline offers greatly decreased friction, less wear, longer life, more dependable operation. It can be fitted with integral gears, clutch dogs, bearing and sprocket seats or a wide choice of other attachments for use with electric, hydraulic or pneumatic units. To convert push-pull to rotary motion, helical types are available with very high leads, ranging from 20:1 to 100:1.

Outstanding opportunities for qualified engineers

Saginaw ball/bearing **Screws and Splines**

SAGINAW STEERING GEAR DIVISION OF GENERAL MOTORS • SAGINAW, MICHIGAN
WORLD'S LARGEST PRODUCER OF BALL BEARING SCREWS AND SPLINES

SEND TODAY FOR THIS FREE 1957 ENGINEERING DATA BOOK . . .
or see our section in Sweet's Product Design File

Saginaw Steering Gear Division
General Motors Corporation
b/b Screw and Spline Operation
Dept. 98, Saginaw, Michigan

Please send new engineering data book on Saginaw b/b Screws and Splines to:

NAME _____

COMPANY _____ TITLE _____

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CITY _____ ZONE _____ STATE _____

TAILORED TO WITHSTAND ENVIRONMENTAL HAZARDS

**Originally introduced as Bendix† Scinseal, this remarkable protective covering for wiring assemblies has achieved wide acceptance because of its versatility and adaptability to virtually any installation condition. Benseal is identical to the product produced under the former name Scinseal.*

If your operations require the use of wiring assemblies which must function in extreme temperature conditions or withstand other environmental hazards, you need the protection of Benseal. It is the perfect protective material for wiring assemblies and usually eliminates the need for metal conduits.

The Benseal process was developed by Scintilla Division of Bendix for the fabrication of wiring assemblies using polyvinyl sleeving and molded junctions. It is formulated to provide wiring with an air-tight seal against operational hazards and gives the protection you need, whether your problem is extreme heat, extreme cold, fuel and acid proximity or, perhaps, a combination of these factors.

Whatever your wiring assembly difficulties may be, it's a good bet that Benseal can help you solve them. It comes in varying colors, each indicating a different function, and can also be hot-stamped to provide positive identification. Many electrical connector adapter molds are available, as well as the T's, Y's and variable molds necessary to provide reliable assemblies of any configuration.

Detailed information and data on Benseal are available on request. SCINTILLA DIVISION OF BENDIX AVIATION CORPORATION, SIDNEY, NEW YORK.

†TRADE MARK.

Scintilla Division
SIDNEY, NEW YORK

Bendix
AVIATION CORPORATION

ENGINEERS:
Write our Employment Supervisor for details of a career with our growing organization.

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LAVELLE... Wherever Precision Fabrication is Required

FAIRINGS
BAFFLES
COWLINGS
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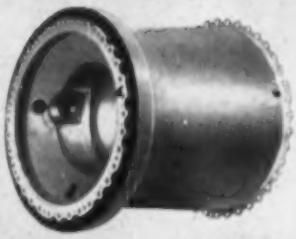
ENGINE MOUNTS

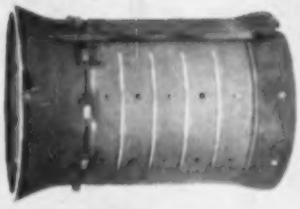
PRECISION WELDED AND MACHINED SHEET METAL PARTS AND ASSEMBLIES

ENGINE DUCTS
SHIELDS
COMBUSTION CHAMBERS
BURNER SUPPORTS
COMBUSTION LINERS



JET ENGINE, MISSILE, ROCKET, AIRFRAME AND ELECTRONIC COMPONENTS

EXHAUST NOZZLES
TAIL PIPES
FLAME HOLDERS
SEALS
ENGINE CASINGS



FABRICATED OF STAINLESS STEEL, TITANIUM, NICKEL AND ALUMINUM ALLOYS

SHELTERS
HOUSINGS
REFLECTORS
CONSOLES
NACELLES

TO GOVERNMENT SPECIFICATIONS BY CERTIFIED MEN, METHODS AND MACHINES

Lavelle's services include engineering production planning, tool making, machine shop and sheet metal facilities . . . inert gas, resistance and metallic arc welding, inspected by X-Ray, Zyglo or Magnaflux, painting, anodizing and quality control.

Lavelle

Lavelle Aircraft Corporation • Newtown, Bucks County, Pa.
Between Philadelphia, Pa., and Trenton, N.J.

Write for this illustrated brochure describing Lavelle's specialized fabricating services in detail.

New from Clary!

"Guided" valves for guided missiles!

high-pressure line valves with 5 choices of actuation!

Now you can "guide" the operation of these valves with 5 different actuation systems–solenoid, pneumatic-hydraulic, manual, explosive or shuttle! A truly complete line of high-pressure line valves.

Here at Clary, our years of experience in manufacturing guided missile components – gyroscopes, servo-actuators, propellant valves, telemetering transducers – now enable us to bring you these high-pressure line valves built with the same precision. Our extensive inspection and quality control guarantee the maximum reliability required of missile components.

When **precision, reliability** and **versatility** are factors in your plans, please call on Clary for complete services, including:

DESIGNING AND TESTING to established specifications and envelope drawings.

PRODUCTION-ENGINEERING of components and complete assemblies covered by your prototype, sketches or drawings.

MANUFACTURING of precision components to established drawings and specifications.

(Shown from top to bottom)

SOLENOID
Hermetically sealed coil
18-30 volts D.C.
Low current consumption

PNEUMATIC-HYDRAULIC
3000 psi operating pressure
Zero leakage
"O" ring seals

MANUAL
Miniaturized toggle action
On-off control
Fixed flow

EXPLOSIVE
Positive on-off action
Trigger release
Protected seat

SHUTTLE
Repetitive reliability
Ideal for final check-out system
Non-interflow

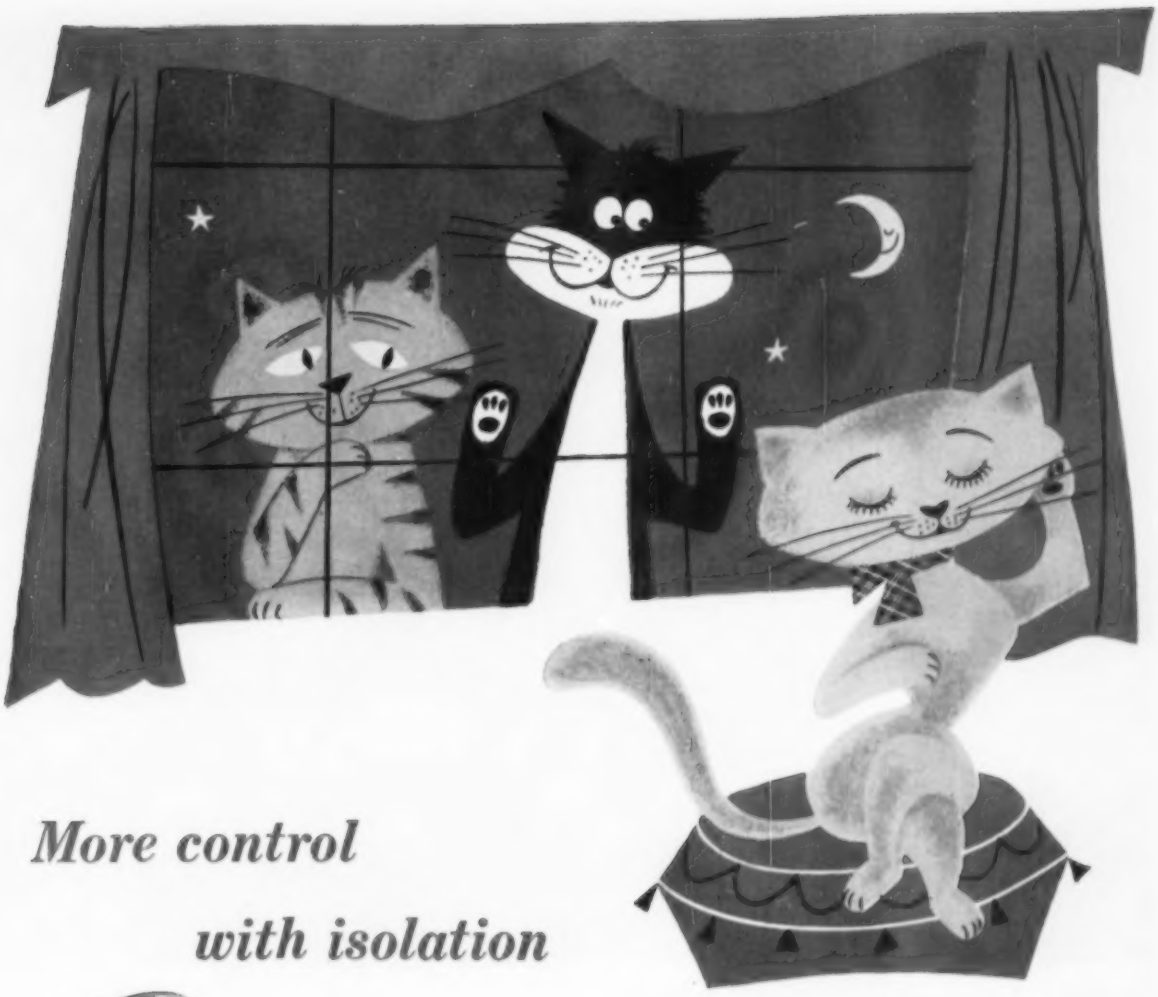
Clary

AUTOMATIC CONTROLS DIVISION

Clary Corporation, Dept. W67,
San Gabriel, California

MANUFACTURER OF BUSINESS MACHINES, ELECTRONIC DATA-HANDLING EQUIPMENT, AIRCRAFT AND MISSILE COMPONENTS

Circle Number 40 on Reader-Service Card



More control with isolation

Although Titanium is one of the most challenging metals ever presented to the aircraft industry, its fabrication into dependable fasteners requires extensive engineering and quality control. Voi-Shan, one of the pioneers in the field, decided that by isolating their Titanium production into a separate division, they would achieve a greater concentration of engineering, production and quality control than ever before possible. A separate, modern plant has been acquired for this purpose. It also means better service and greater facilities for solving your particular Titanium fastener problems. Why not submit your Titanium needs to your local Voi-Shan representative, or write for the booklet, "Voi-Shan Reports on Titanium."

VOI-SHAN

MANUFACTURING COMPANY

A division of PHEOLL MANUFACTURING COMPANY

8463 Higuera St., Culver City, California

Offices in principal cities of the United States and Canada

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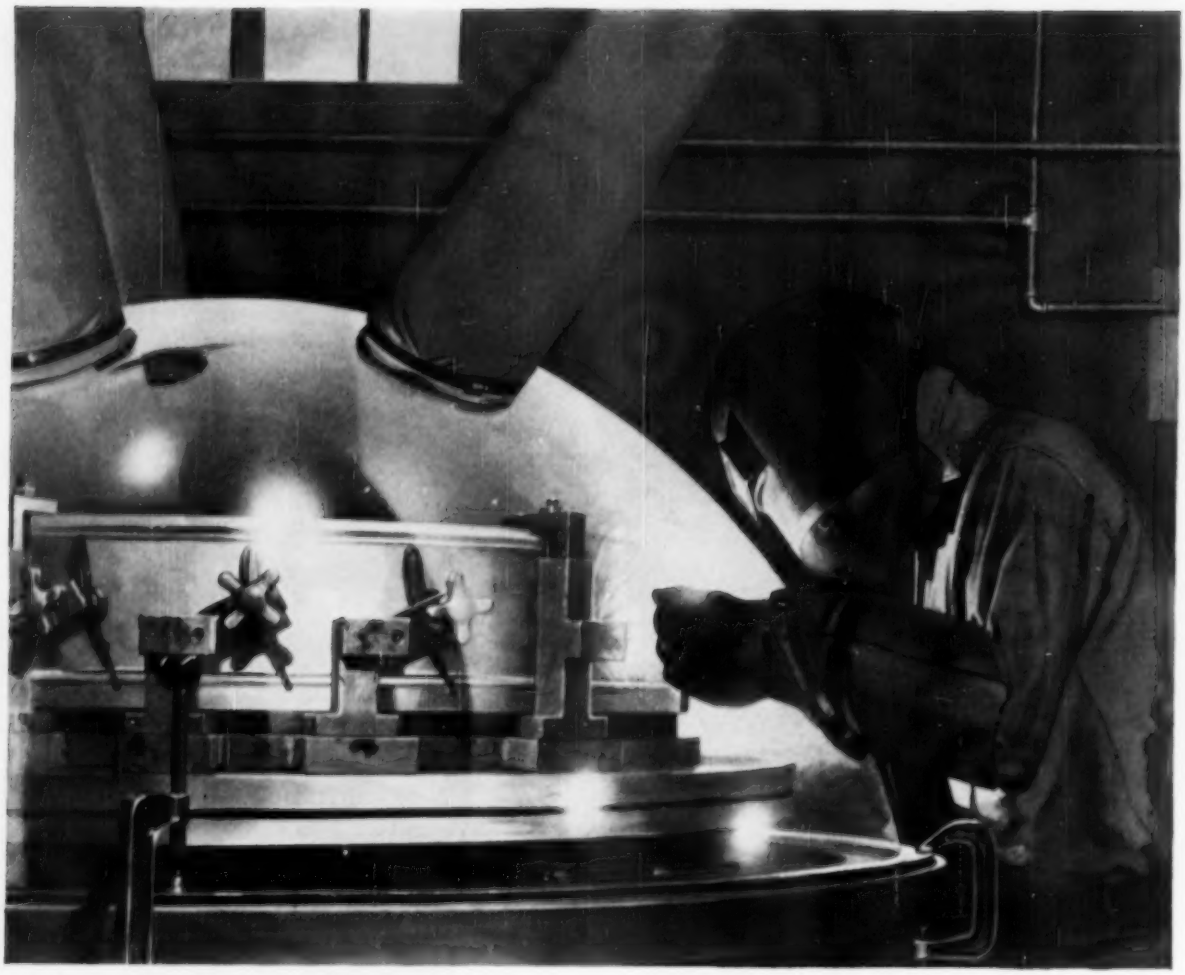


Solar Advanced Technology

Taming hard-to-work titanium with "purge chamber" welding

AIRCRAFT AND MISSILE DESIGNERS call for more and more titanium. The superior strength-to-weight ratio of this new metal saves vital pounds in airframe, engine and missile components. Solar is leading the way in taming this hard-to-work metal.

The plastic purge chamber, shown above, is a Solar development to facilitate welding of titanium in an atmosphere which protects the weld from elements in the air. It is one of many advanced fabricating techniques perfected in Solar laboratories to help realize titanium's promise. As a result, Solar today is among the largest users of titanium for aviation purposes, and is constantly testing and working with new materials requiring experience and expert ability.

This is one example of Solar advanced technology—a combination of skills, facilities and forward-looking pioneering. Perhaps Solar can bring a fresh viewpoint to your difficult metal-working problems. Write to Department D-31, Solar Aircraft Company, San Diego 12, California.

SOLAR
AIRCRAFT COMPANY
SAN DIEGO DES MOINES

ENGINEERS WANTED *Unlimited opportunities, challenging projects, good living with Solar! Write for new brochure.*

New "Solar Advanced Technology" facilities brochure is of value to you . . . Write for it.

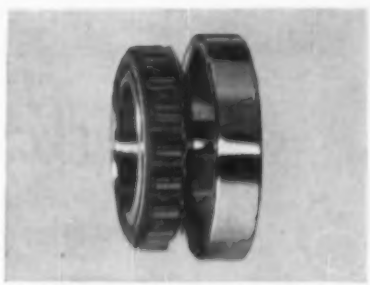
DESIGNERS, DEVELOPERS AND MANUFACTURERS • GAS TURBINES • AIRCRAFT AND MISSILE COMPONENTS • BELLOWS • CONTROLS • COATINGS • METAL ALLOY PRODUCTS

Circle Number 42 on Reader-Service Card

Margin for Error . . . *None!*

You swing into your final approach. At precisely the right instant the Landing Signal Officer flags you to cut your power—and you're aboard! ☆ Such skill and precision is indicative of that which is required today in *every* phase of the aircraft industry. The bearings in modern jet turbines, for instance, must be held to accurate tolerances measured in millionths of an inch. That's why the leading jet turbine manufacturers specify Bower aircraft bearings first. Their exceptional high quality and unerring precision allow Bower bearings to stand unbelievable turbine speeds and temperatures—that match the supersonic speeds of today's jet aircraft—*with a minimum of lubrication.* ☆ Whatever *you* produce, if it uses bearings, specify Bower! Choose from a complete line of tapered, straight and journal roller bearings for every field of transportation and industry.

BOWER ROLLER BEARING DIVISION
FEDERAL-MOGUL-BOWER BEARINGS, INC. • DETROIT 14, MICHIGAN



IDEALLY SUITED TO HIGH-SPEED OPERATION

Built to hold their precision indefinitely, these aircraft bearings are recommended wherever superior quality and high-speed operation are required. For some applications, a special alloy steel—developed jointly by Bower and several aircraft companies—is used.

BOWER ROLLER BEARINGS

Circle Number 43 on Reader-Service Card

New!

DPS Connectors for High Altitudes-Vibration

These rack/panel pressurized connectors are designed for high altitude and vibration applications. When the DPS connector is mated, it is sealed about the insert faces by means of a specially designed rubber seal, that allows an axial tolerance of up to ⅛" while still effecting a seal. This seal is encased in the #34 shell so that the step down design of the mating #33 shell seats into and against it. In addition, the #34 or pin insert shell encloses a monobloc silicone insert designed so that the tightening of the junction shell effects a compression seal around the wires that have been inserted. The #33 or socket insert shell has a plastic front insulator, to insure alignment of contacts, and is backed up by a silicone rear insulator that is also tapered to permit the corresponding taper of the junction shell to compress it around the wires as the junction shell is tightened. Contacts for DPS connectors must be ordered separately, and installed at time of wiring. Co-axial contacts, and thermocouple contacts are available. Also, air lines. DPS connectors are available in 4 different sizes with several insert arrangements for each size.

Write for Bulletin DP-101 TODAY!

WHAT'S NEW FOR YOU

New!

Coaxial Connector Screw Type Coupling

TNC Coaxial Receptacle SA-445

Latest RF Connector Series — The TNC. The TNC is a screw type coupling version of the improved BNC series for small coaxial connectors. This TNC series, made by the Eastern Division of Cannon Electric, is available in two types: low voltage and high voltage. Both types are ideal where minimum noise is desired. They are lightweight, waterproof, sealed connectors which will operate at any altitude.

The high voltage TNC is recommended for AC rating up to 5,000 volts. Low voltage rating is to 500 volts. The TNC series is also available with collet cable clamp.

Write for RF Coaxial Bulletin DC-1 TODAY!

IN CANNON PLUGS

New!

Quick-Disconnect Accessories for AN-Plugs

CA06BQ Plug CA02AQ Receptacle

An accessory that consists of coupler and an adapter has been recently perfected by Cannon to provide quick connect and quick disconnect characteristics to AN connectors.

The adapter is designed to screw over the coupling threads of a standard AN receptacle, and contains an external locking groove which receives the formed ends of the coupler latch when fully engaged. The entry of the coupler latch into this groove permits a compression spring to move the coupler sleeve forward, locking the parts securely. A simple straight pull back on the sleeve releases the latch and permits disconnection.

The coupler consists of a special spring latch assembly, and is designed to replace the coupling nuts on Cannon AN3106A and AN3106B plugs.

Write for Bulletin PR-QD TODAY!

CANNON PLUGS
WHERE RELIABILITY IS THE 5TH DIMENSION

CANNON ELECTRIC

Please refer to Dept. 110

CANNON ELECTRIC CO., 3208 Humboldt St., Los Angeles 31, California. Factories in Los Angeles, Salem, Mass., Toronto, London, Melbourne. Manufacturing licensees in Paris, Tokyo. Representatives and distributors in all principal cities.

Circle Number 44 on Reader-Service Card

Toward new frontiers of flight

Trimming vital years from the nation's aircraft development program, A-C equipment is aiding in research by the USAF's Wright Air Development Center, NACA's Langley and Moffet Fields, and major producers of aircraft and engines.

AEDC Consulting Engineers: Sverdrup & Parcel, Inc.

Allis-Chalmers Compressors

develop supersonic and hypersonic air speeds to test planes and missiles

Flight conditions at two, three, ten times the speed of sound are duplicated with scale models and for full-size jet engines at the U. S. Air Force's Arnold Engineering Development Center, Tullahoma, Tennessee.

This photo shows some of the Allis-Chalmers equipment used to whip up these tremendous air speeds.

Axial and centrifugal compressors with a combined rating of four and one-half million cubic feet of air a minute... driven by 300,000 horsepower of electric motors, with all necessary power transformers and control equipment, are among the drive systems installed in the Center's three laboratories.

Allis-Chalmers furnishes axial flow, centrifugal and rotary compressors for all wind-tunnel and engine test applications.

Other Equipment Available to Simplify Engineering

Allis-Chalmers also builds transformers, control, switchgear, motors, and unipolar generators for use in wind-tunnel and test facilities. For information, contact your nearby A-C office or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS

Circle Number 45 on Reader-Service Card

A-5429

MELETRON

YOUR ELECTRIC-HYDRAULIC LINK

OUR BUSINESS IS PRESSURE ACTUATED SWITCHES

WE take a lot of pardonable pride in considering ourselves leaders in the design and development of Pressure Actuated Switches . . . From Absolute Zero to 15,000 psi . . . Chances are there is a Meletron Pressure Actuated Switch in our standard line that will meet your requirements . . . With us pressure and vacuum actuated switches come FIRST. For more than 20 years we've been building aircraft and industrial pressure switches. We know we have pressure switch 'know-how' . . . And, if one of our regular model Meletrons doesn't solve your particular pressure control problem, then we'll build one that will.

MELETRON CORPORATION

950 NORTH HIGHLAND AVENUE • LOS ANGELES 38, CALIFORNIA

ENGINEERS AND MANUFACTURERS

Circle Number 46 on Reader-Service Card

Circle Number 47 on Reader-Service Card →

Important News!... **FROM TRANSISTOR CENTER, U.S.A.**

NOW...a full selection of PHILCO *Transistors*

For Reliable Performance . . . Stability of Operation . . . Long Life!

ACTUAL SIZE

MINIATURE LOW LEVEL AUDIO TRANSISTORS (25 mw)

2N207	general purpose micro-miniature low level transistor, typical beta of 100, 15 db maximum noise figure
2N207A	10 db maximum noise figure version of 2N207
2N207B	5 db maximum noise figure version of 2N207
T0031	50 volt version of 2N207

Special versions of the 2N207 to selected beta ranges are available.

HIGH FREQUENCY, HIGH GAIN (MICRO ALLOY) TRANSISTOR

T1166	combines high frequency response with high gain for general purpose high frequency applications and switching circuits, typical f_{max} 60 mc

HIGH FREQUENCY SILICON TRANSISTORS (150 mw)

T1025	general purpose, 10 mc silicon transistor
T1159	high speed silicon switch for speeds up to 5 mc characterized by extremely low switch resistance

ACTUAL SIZE

HIGH FREQUENCY SURFACE BARRIER TRANSISTORS

SB100	general purpose, minimum f_{max} = 30 mc, beta over 10.5
2N344/ SB101	general purpose, good beta control (11-33)
2N345/ SB102	general purpose, higher beta (25-110)
2N346/ SB103	general purpose, higher minimum f_{max} (60 mc)
2N128	general purpose, with military specifications, beta 19-66, minimum f_{max} 45 mc
2N129	general purpose, with military specifications, beta over 11.5
2N240	switching transistor, $f_{\alpha cb} > 30$ mc
2N299	for tuned amplifiers, military specifications, 20 db minimum power gain at 10 mc, minimum f_{max} 90 mc
2N300	for video amplifiers, 50 mc minimum current gain bandwidth product, f_{max} over 85 mc
T1050	high frequency transistor for 50 mc oscillator mixers and 10-15 mc bandpass amplifiers, 22 db typical power gain at 10 mc

Other types with special parameter controls are available.

ACTUAL SIZE

MEDIUM POWER ALLOY JUNCTION AUDIO TRANSISTORS (100 mw)

2N223	39-120 beta driver transistor
T1000	45-85 beta version of 2N223
T1001	70-120 beta version of 2N223
2N224	high gain output transistor, 2N225 is a matched pair
2N226	medium gain version of 2N224, 2N227 is a matched pair

Versions of the 2N224 with various beta ranges and higher betas are available singly or in matched pairs.

AUDIO POWER TRANSISTORS

T1040	40 volt, 7 watt power transistor, thermal drop 3°C/w maximum
T1041	40 volt, 10 watt power transistor, thermal drop 2.5°C/w maximum
T1167	60 volt, 12.5 watt power transistor
T1168	80 volt, 12.5 watt power transistor

Proven performance of Philco Hermetically Sealed Transistors has made them the basis for design in commercial and military applications where reliability is the major consideration. Philco transistors range from the world's smallest germanium transistors now in production to silicon transistors with excellent performance at temperatures from −60°C to +150°C.

Philco produces a wide range of transistors designed for special applications in accordance with customer requirements. The Philco Micro-Alloy Transistor is in production. Specifications and design quantities are available. New and exciting transistor types, such as the Philco Micro-Alloy Graded Base Transistor, are now in development. In keeping with our policy, specifications will be made available as soon as these units reach pilot production and are available in design quantities.

Make Philco your prime source for complete transistor application information . . . write to Lansdale Tube Company, Dept. 1-2, Lansdale, Penna.

Regional offices—Merchandise Mart Plaza, Chicago 54, Ill.—10589 Santa Monica Blvd., Los Angeles 25, Calif.

PHILCO CORPORATION

LANSDALE TUBE COMPANY DIVISION

LANSDALE, PENNSYLVANIA

The new pride of Eastern...
PROTECTED BY SINCLAIR

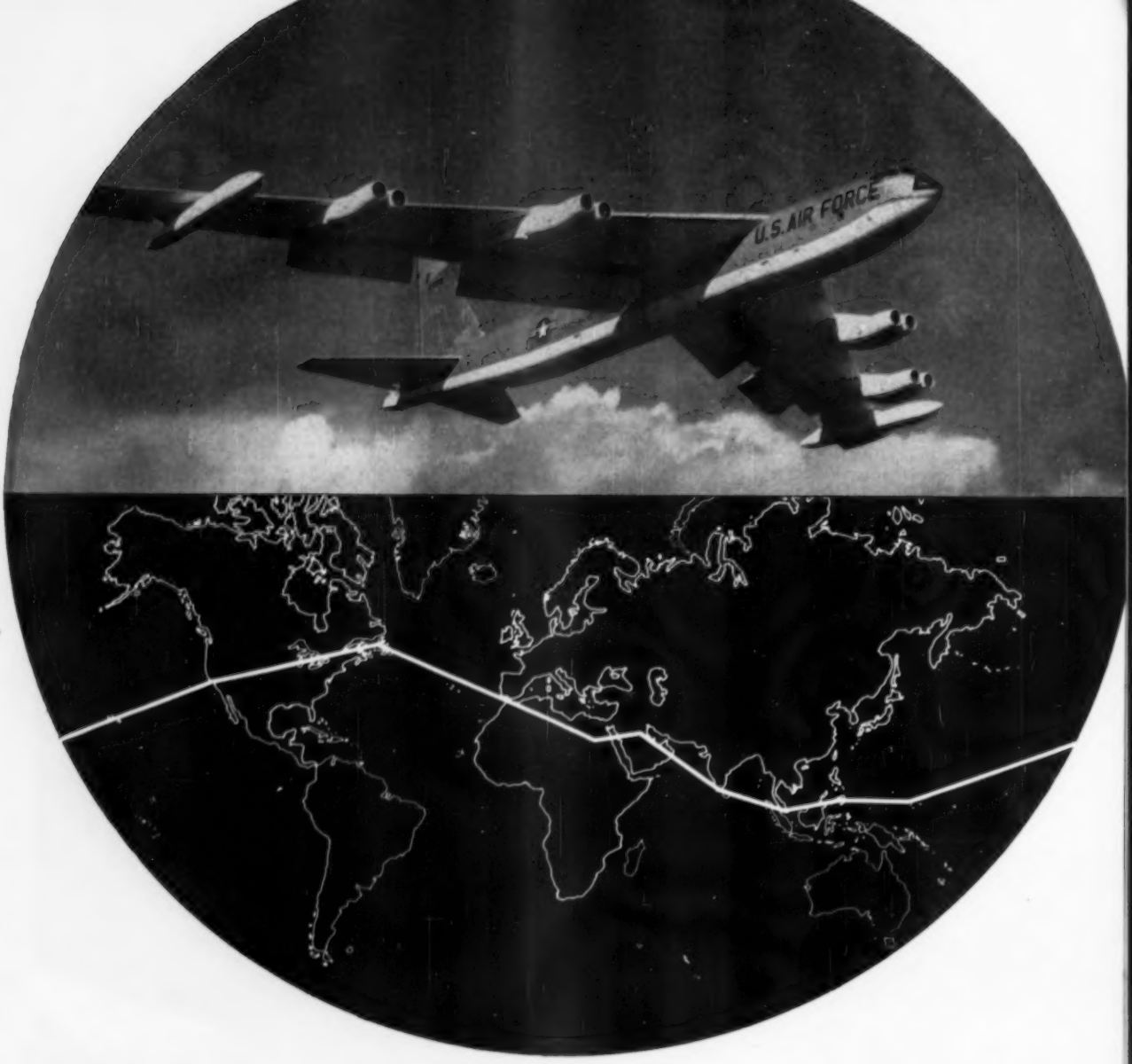
Latest Eastern Air Lines plane to bear the illustrious Golden Falcon name is the Super G Constellation. This new titan of the skies carries 70 passengers – has an increased cruising range and includes 107 new design features. It embodies new luxury, style and comfort – retains its traditional dolphin-like grace and triple tail.

Its four great Turbo Compound engines that generate 13 thousand horsepower are protected with Sinclair Aircraft Oil. Eastern uses Sinclair Aircraft Oil *exclusively* because of its proved quality and dependability over the years. In fact, today 45% of the aircraft oil used by major scheduled airlines in the U.S. is supplied by Sinclair. There's no better proof of reliability.

SINCLAIR AIRCRAFT OILS

Sinclair Refining Company, Aviation Sales, 600 Fifth Ave., New York 20, N. Y.

N6235G
SUPER-G



THE FLIGHT HEARD 'ROUND THE WORLD

Recently three B-52 bombers flew around the world in 45 hours and 19 minutes. They were only specks in the vastness of the sky, yet they were in voice-contact every mile of the way—with SAC headquarters in Omaha, with each other, with bases along the route and with the KC-97 tankers that refueled them in the air.

Their speed-of-light contact was the AN/ARC-21 liaison communications set in each of the ships. This is a long-range, pressurized, high-altitude airborne system, capable of world-wide communications. It may be operated by the pilot, so no radio operator is needed. It is characterized by minimum training requirements, simplified maintenance, high reliability, positive channel selection —with a choice of any 20 of 44,000 frequencies.

In this as in other ways, RCA serves our Nation's armed forces. RCA scientists and engineers are constantly creating, designing and producing new and better electronic systems and equipment.

RCA Tmk(s) ®

RADIO CORPORATION of AMERICA

DEFENSE ELECTRONIC PRODUCTS — CAMDEN, N. J.

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Why CHANCE VOUGHT *Chose* menasco

...*Because* MENASCO COULD MEET THE CHALLENGE OF COMPACT, STRONGER, LIGHTER LANDING GEAR FOR HIGH SPEED NAVY AIRCRAFT

CHANCE VOUGHT record-breaking *Crusader* jet fighters require extremely rugged landing gear to operate from aircraft carriers. The designs for the main and nose gear called for great strength in order to absorb maximum sink speeds and arresting tension; the weight-saving combination of steel and aluminum; and the highest mechanical specifications.

MENASCO was chosen to fabricate the *Chance Vought Crusader* landing gear and not only *met* but *exceeded* all requirements. The gear is the lightest, strongest and most compact of any carrier aircraft. *Menasco's* advanced ideas in the application of materials and progressive techniques in precision production of landing gear assures *built-in quality and reliability.*

first in development, quality, delivery and service.

menasco manufacturing company

BURBANK, CALIFORNIA • FORT WORTH, TEXAS

SPECIALISTS IN AIRCRAFT LANDING GEAR

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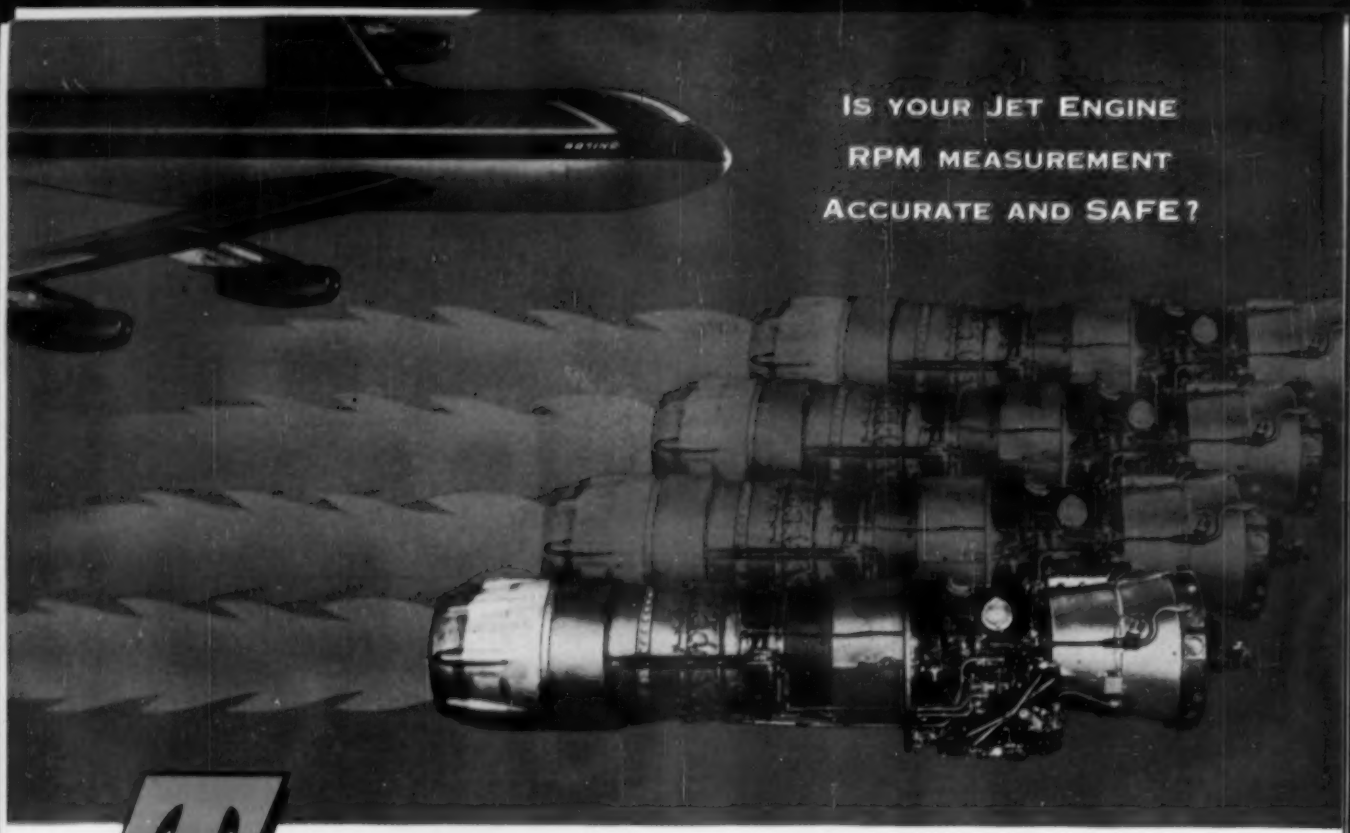


TAKCAL®

READS JET ENGINE SPEED to GUARANTEED ACCURACY of 10 RPM in 10,000 RPM (±0.1%)

The inter-relation of RPM to efficiency and thrust in jet engines is fundamental. Proper adjustments for maximum thrust, maximum engine life and maximum safety of operation can be made only upon accuracy of instrumentation. The TAKCAL tests to guarantee that accuracy.

The new B & H TAKCAL incorporates a refinement of the frequency meter principle. It operates in the low (0 to 1000 cps) range, reading the frequency of the tachometer generator on a scale calibrated in percent RPM corresponding to the engine's RPM. It reads engine speed while the engine is running with a guaranteed accuracy of ±0.1% in the range of 0 to 110% RPM. Additionally, the TAKCAL circuit can be used to trouble-shoot and isolate errors in the aircraft tachometer system, with the circuit and tachometer paralleled to obtain simultaneous reading.

The TAKCAL's component parts are identical with those used in the J-Model JETCAL Analyzer. They are here assembled as a separate unit tester and for use with all earlier models of the JETCAL Tester.

The TAKCAL operates accurately in all ambient temperatures from −40°F. to 140°F. Low in cost for an instrument of such extreme accuracy, it is adaptable to application in many other fields.

For full information write or wire...

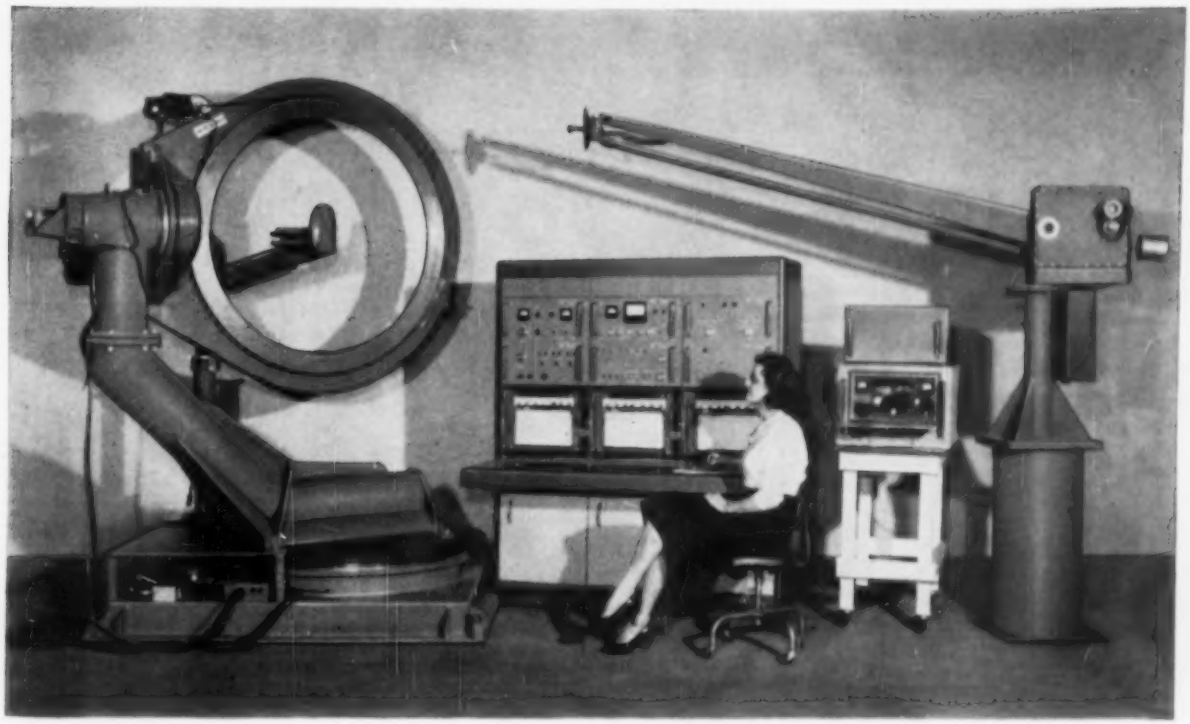
B & H makes the *JETCAL*® Analyzer and *TEMPCAL*® Tester

B & H INSTRUMENT CO., INC.

3479 West Vickery Blvd. • Fort Worth 7, Texas

Sales-Engineering Offices:

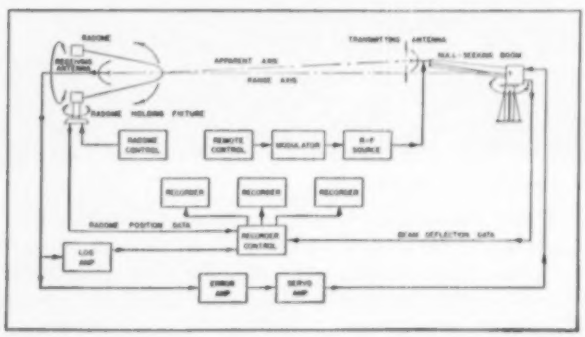
VALLEY STREAM, N. Y.; 108 So. Franklin, LO 1-9220 • DAYTON, OHIO; 209 Commercial Bldg., MI 4563 • EL SEGUNDO, CAL.; 427 E. Grand Ave., EA 2-1644



TEST RADOMES AUTOMATICALLY

with the CTI Radome Boresight-Error Measuring System

The effectiveness of the best airborne radar tracking system can be completely destroyed by deflection of the radar beam as it passes through the plastic radome. Radome manufacturers and aircraft and engineering firms installing and testing radar equipment, faced with the tedious problem of measuring beam shift at various points on the radome, now have a fast and accurate method at their command. The CTI Radome Boresight-Error Measuring System automatically records beam deflection as a continuous function of the radome position, requires far less time than previous methods, and does not miss discontinuities often overlooked in point-by-point measurements.



RECORD BORESIGHT ERROR DIRECTLY WITH AN OVERALL SYSTEM ACCURACY OF ¼ MILLIRADIAN (1/70°)

As the motor-driven holding fixture rotates the radome under test, the servo-controlled, null-seeking antenna on the boom traces the position of the deflected radar beam. At the control console, under supervision of a single operator, three recorders plot the total magnitude and the horizontal and vertical components of the beam deflection angle directly in milliradians. Rate of change of the beam deflection, essential to missile applications, is readily obtainable from the recordings.

Additional features include automatic plotting of antenna patterns with or without the radome, and radome transmission efficiency measurements.

For additional information write to Dept. 6-63

Visit us at the National Convention on Military Electronics
Washington, D. C., June 17, 18, and 19, Booth No. 37.

Engineers: Career opportunities are currently available.

CALIFORNIA TECHNICAL INDUSTRIES
Formerly COLOR TELEVISION INCORPORATED

CTI

BELMONT, CALIFORNIA

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Circle Number 53 on Reader-Service Card

PLANE FAX

by STANDARD OIL COMPANY OF CALIFORNIA

Air-to-ground "talk" speeds mountain rescue

Lost in the high forests of Southwest Utah with cold and darkness closing in! It looked like an unpleasant night ahead for a mother and her four young children who had strayed from their party. Then state police called Royce Knight for help. In less than two hours he combed a hundred square miles of rough country, spotted the lost family's campfire, and led the ground party to them by walkie-talkie!

"Low-level night flying isn't much fun," says Mr. Knight, "but it's not too bad when you're sure of your engine. I can count on full power every minute I'm in the air, with Chevron Aviation Gasoline. It never fouls plugs, gives me extra power when I need it, and still lets me lean back for economy at cruising speed.

"Flying out of Cedar City, I do a lot of crop dusting and spraying — the kind of work that's toughest on an engine. I make sure my planes stay in top shape by using RPM Aviation Oils. I'm getting 200 extra flying hours between overhauls since I switched to 'RPM.' Parts stay clean and free, valves never stick, bearings are perfect."

TIP OF THE MONTH

When flying on the lee side of a mountain crest or ridge, remember that downdrafts will make your altimeter read "high." It's possible to be in a steady descent and still get "constant altitude" readings.

We take better care of your plane

CHEVRON AVIATION GASOLINE

AVIATION OILS RPM

T.M.'S "RPM," "CHEVRON," "PLANE FAX," REG. U. S. PAT. OFF.

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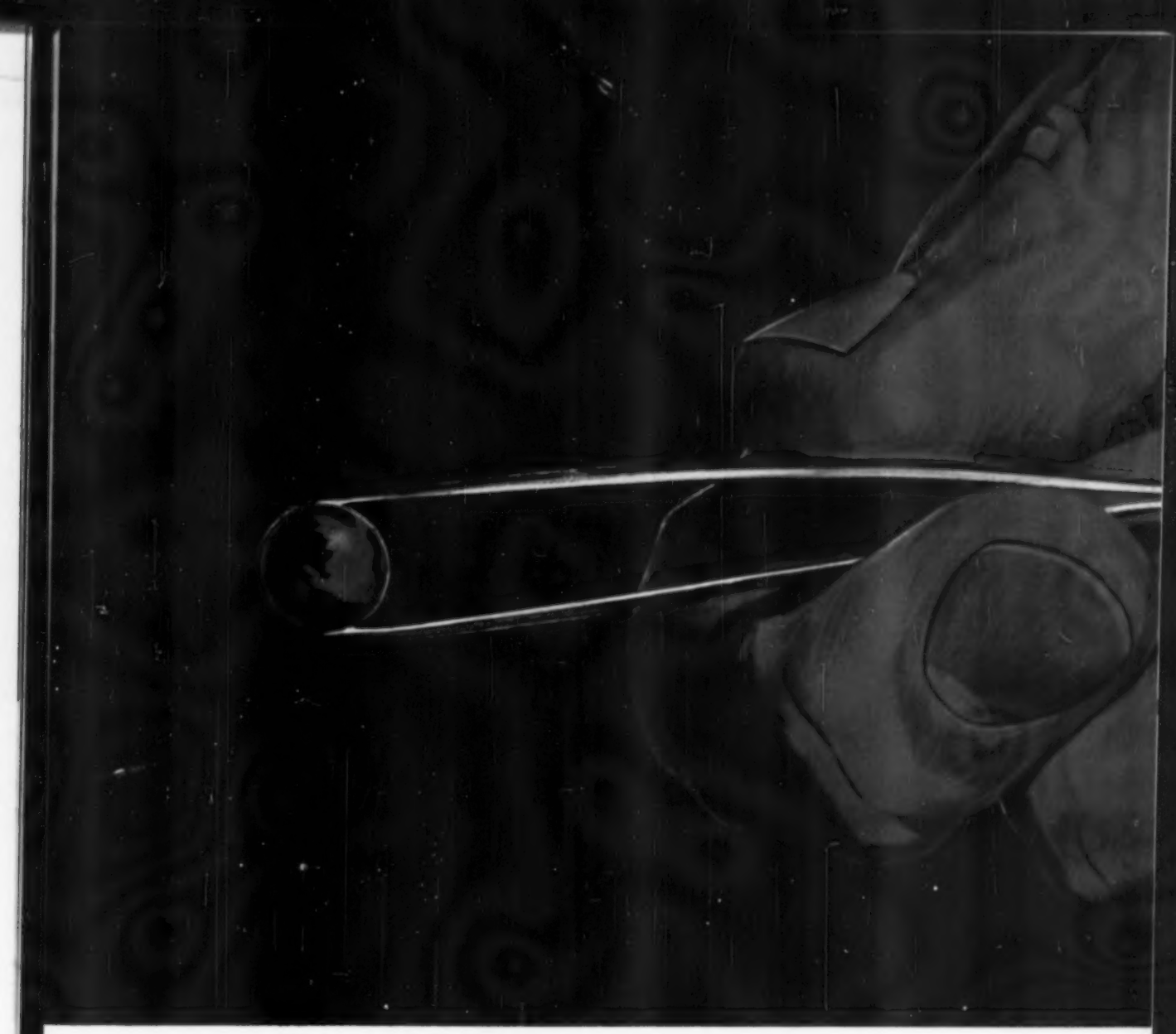
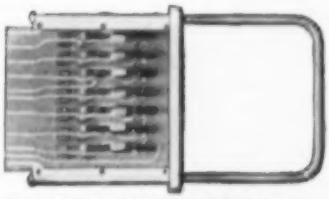


SMALL WORLD—The world of the diode... the transistor... the printed circuit... the new magnetic and dielectric components—this world expands in significance as it shrinks in physical proportions. Popularly symbolized by the tinier-than-ever hearing aid and the pocket radio, the new, small world of solid state circuitry is omnipresent. It safeguards our skies. It simplifies our living. It opens new doors to learning.

Stewart-Warner Electronics has pioneered in the development of solid state circuitry. Out of a manufacturing environment second to none, Stewart-Warner Electronics is mass-producing equipment containing solid state devices by the thousands of units.

Your problem of solid state circuit design and production techniques will be handled at Stewart-Warner Electronics with equal efficiency. If you are an engineer interested in advanced circuit development, write: Stewart-Warner Electronics, Dept. 14, 1300 North Kostner Avenue, Chicago 51, Illinois.



One of 160 plug-in modules for the desk-size Stewart-Warner Data Processing Unit. Modules employ solid state circuitry to save space and eliminate many vacuum tubes.

STEWART SW WARNER **ELECTRONICS**

a Division of Stewart-Warner Corporation

Circle Number 55 on Reader-Service Card

Johns-Manville structural insulations offer you unparalleled design flexibility

Proof of this design flexibility can be seen in the intricately designed structural insulations Johns-Manville is now producing for the aviation industry.

Precision formed through recently developed methods, Johns-Manville structural insulations meet the exacting design specifications of aircraft manufacturers. They provide the closer temperature control needed for supersonic performance.

And—equally important—they are integral structural parts that resist vibration and corrosion to keep maintenance and replacement at a minimum.

J-M aircraft and missile insulations are made of high-heat resistant alloys enclosing Thermoflex® refractory fiber felt. The finished part is light in weight, yet possesses unusual structural strength and rigidity.

So whether you're in the blueprint stage or in prototype testing, whenever and wherever you need HEAT control—call in J-M. Our insulation specialists will give you the design help you need . . . the very latest information on insulation methods employing stainless steel, titanium and other light-weight, heat-resistant alloys.

Write Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ont.

Insulated Structural Panel Assembly

Insulated Engine Shroud

Insulated Structural Part

Johns-Manville PRODUCTS FOR THE AVIATION INDUSTRY

Circle Number 56 on Reader-Service Card

Photographed on ¼ in. graph paper

Build smaller, lighter electrical assemblies with new Airborne miniaturized capacitors

You can now reduce the weight and bulk of electrical and electronic components still further with Airborne's new miniaturized capacitors.

Utilizing Mylar dielectric and a special conductor, these new Airborne capacitors have exceptionally high microfarad ratings per cubic centimeter—up to 12 times higher than those of ordinary capacitors.

Airborne miniaturized capacitors are rated at 200 v d-c and have an operating temperature range of −75°F to +300°F with a capacitance change of only 12%. At 300°F they will withstand 150% rated voltage for 250 hours through a resistance of 1 ohm per volt.

Available with 3 terminal options, Airborne standard design miniaturized capacitors are furnished in hermetically sealed metal containers to meet Government specification MIL-C-25A.

Write, phone or wire for more information and quotations

Airborne Miniaturized Capacitors—200 v d-c

Microf. (±10%)	Dia.	Length
.25	3/8	1¼
.5	½	1¼
1.0	5/8	1¼
3.0	⅞	1⅛
4.0	1	1⅛
5.0	1 1/16	1⅛
6.0	1¼	1⅛
7.0	1 5/16	1⅛
8.0	1 3/8	1⅛
9.0	1½	1⅛
.25	3/8	¾
.4	½	¾
.75	5/8	¾
1.5	1	¾
18.0	1¾	2¼

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New technical bulletin covering Airborne miniaturized capacitors available on request.

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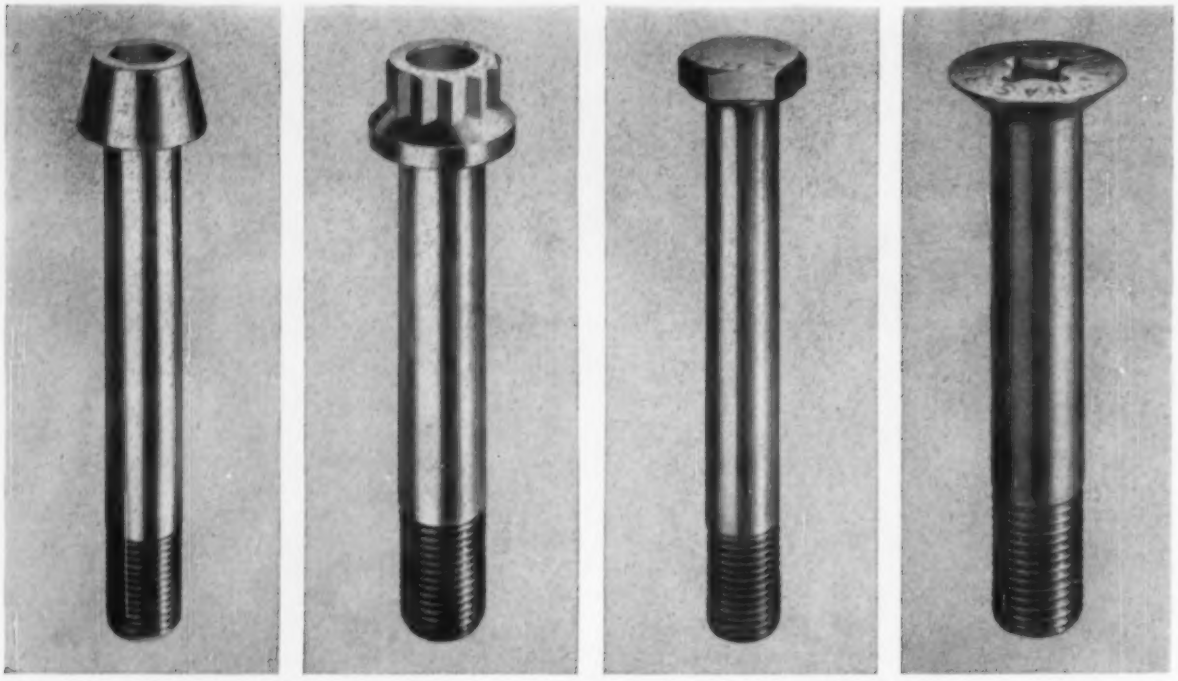
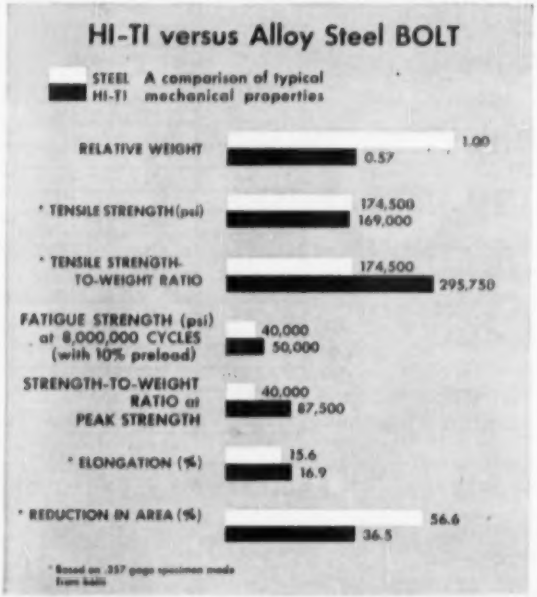


SPS Hi-Ti titanium aircraft bolts are regularly manufactured in four standard configurations: internal wrenching tension bolts, 12-point external wrenching tension bolts, hexagon head external wrenching shear bolts, and flush head internal wrenching shear bolts. Weighing 43% less than steel bolts of equivalent dimensions, they can save you as much as 1000 lb. per airframe—with no loss in strength.

SPS Hi-Ti titanium bolts help you build lighter airframes without sacrificing strength



Hi-Ti vs. alloy steel. Tensile, elongation and reduction area properties are based on the performance of bolt gage specimens. Endurance limit was determined by subjecting bolts to tension load alternating between maximum and 10% preload for a total of 8,000,000 cycles without inducing failure. Significant comparison is the strength-to-weight ratio at endurance limit.

SPS Hi-Ti titanium bolts help you solve the problem of reducing airframe weight without compromising strength. They weigh 43% less than alloy steel bolts of the same size. One lb. of them can do the work of 1¾ lb. of steel bolts. Yet in tensile-strength-to-weight ratio and fatigue resistance, they outperform steel.

Once considered a laboratory curiosity, titanium bolts have for some time been standard production items at SPS. Hi-Ti bolts are found in many advanced design operational aircraft. This is because SPS—producer of the first successful titanium aircraft bolt—invested over $500,000 and several years of high priority research in learning how to deal with this promising but sensitive metal. Today SPS has the most extensive facilities in the industry for the production and testing of titanium fasteners. As a result, we can give you both the technical assistance and the delivery you need to utilize fully the advantages of titanium bolts in your current airframe projects.

For more information on Hi-Ti titanium aircraft bolts, write Aircraft Products Division, STANDARD PRESSED STEEL Co., Jenkintown 3, Pa.

STANDARD PRESSED STEEL CO.

AIRCRAFT PRODUCTS DIVISION

SPS

JENKINTOWN PENNSYLVANIA

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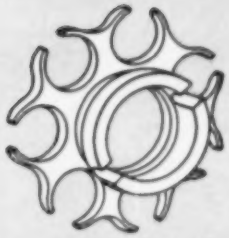
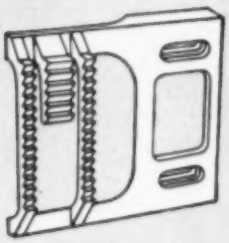
Here is an example of the complex internal coring possible with investment casting. Square, round, elliptical or irregular interiors can be cast.



The complexity of this part makes investment casting the only feasible method of manufacture. Prongs have perfect dimensional accuracy.

Here an entire assembly incorporating multiple functions is cast in one unit. "Keyhole" coring and a number of distinct surface details are required.

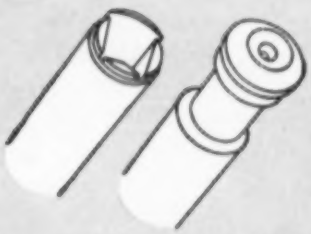


The sharp teeth of this sewing machine feed dog were cast in wear-resistant alloy to give longer wear than could be obtained from machinable material.

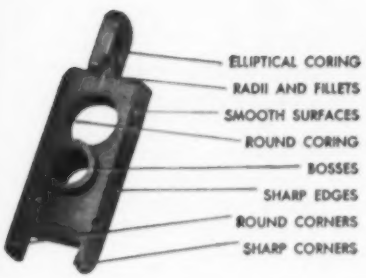
design with austenal in mind

In planning parts, design directly for Microcast and take advantage of its wide range of design possibilities.

See not only what you can do, but what costly, time-consuming operations Austenal investment casting eliminates.

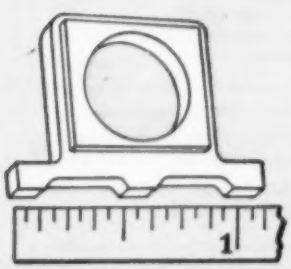


Cross-sections of irregular and varying thickness can be utilized. In this part the internal core diminishes from an irregular square to a small round hole.

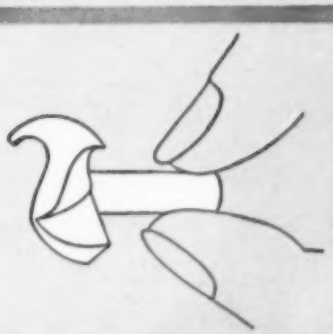


These extrusion dies of wear-resistant alloy are readily mass-produced with highly complex and irregular internal contouring.

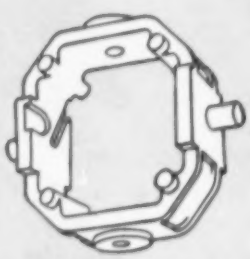
Walls of varying cross-sections are possible. Here wall thicknesses change from thin to very heavy, allowing strength without bulk.



This very small part measures 1⅛" wide and less than ⅛" thick. Its thinness, rigidity and detail were possible only by investment casting.



Shown here is an example of how investment casting can virtually eliminate hand-filing and machining by keeping uniform, intricate detail.



This large complex gimbal was cast to include many details on the internal and external surfaces.

Design problem?

Call your Austenal representative and ask him to show you how Microcast can help you.

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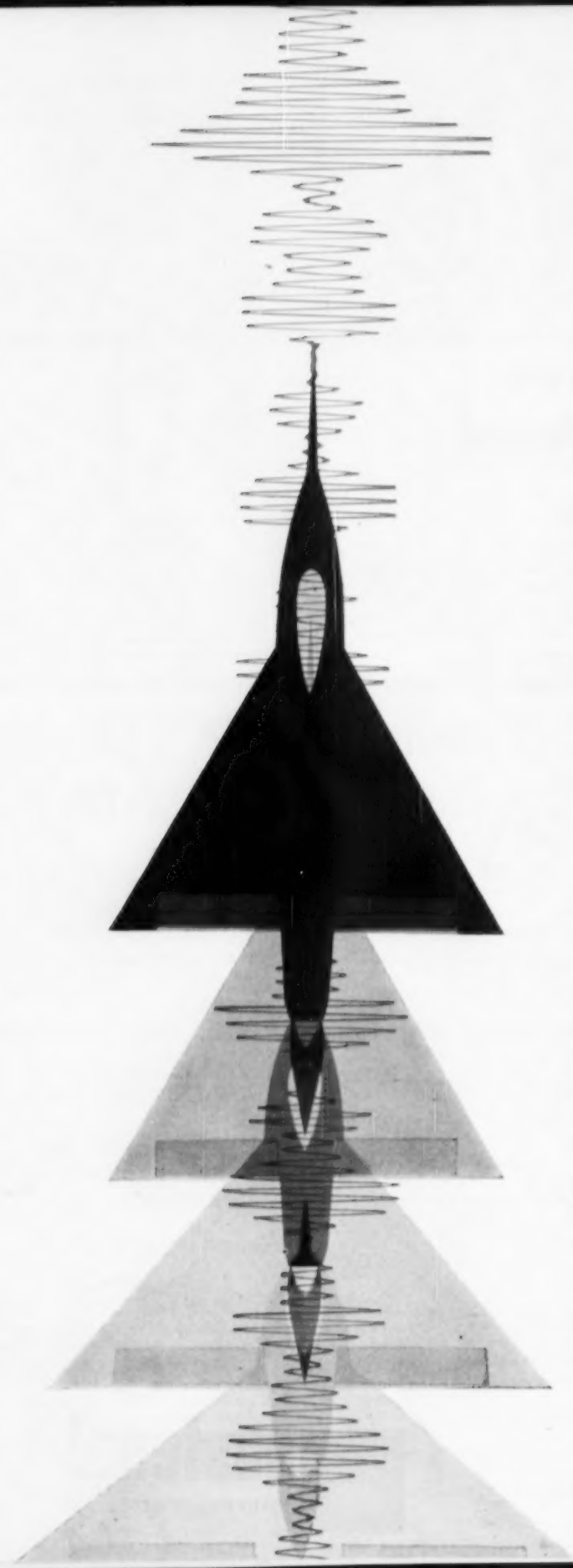

KEEPING INSTRUMENTATION A STEP AHEAD OF SPEED

AVIONICS IN ACTION AT BURROUGHS:

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Today's dramatic new developments in aircraft performance demand equally dramatic new developments in flight *instrumentation*. And Burroughs is assuming ever greater responsibilities in this field through its work in the brand-new science of *avionics*.

Examples? Past experience in mass production of such instruments as altimeters, accelerometers and gyros. Plus, of course, extensive research and development in totally new concepts of flight instrumentation. And in all these enterprises, *reliability* consistently keynotes our performance.

We have, too, the capabilities and facilities for further research and development in this fast-moving field. And in all areas of our proved responsibility and competence—not only instrumentation but control systems, electronic computation, communications, data processing and others—we stand ready to see defense contracts *all the way* through. Yes, from preliminary research to installation and field service.

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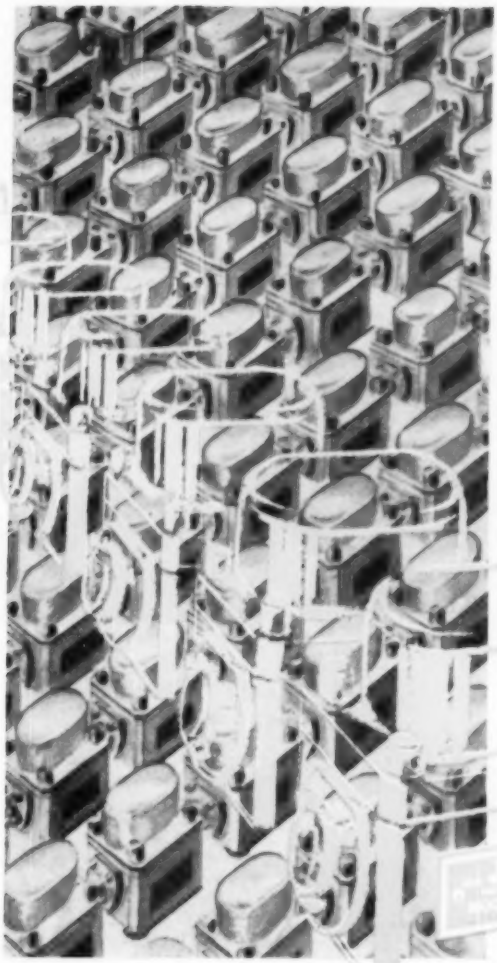

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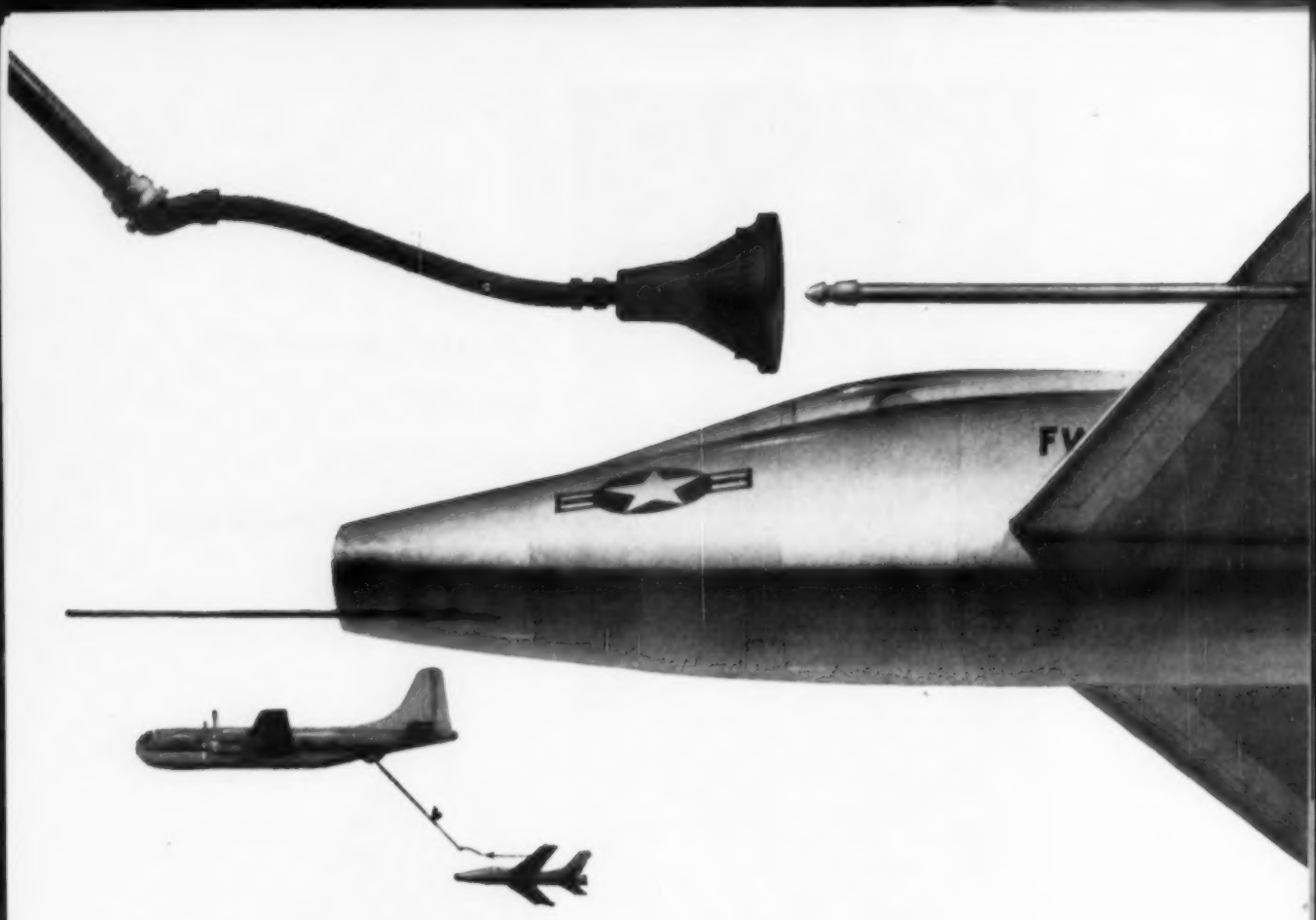

NEW VERSATILITY FOR THE AIR FORCE

----BY SCHULZ AND W.A.D.C.

Developed jointly by Schulz Tool & Mfg. Co. and Wright Air Development Center, this new aerial refueling adapter quickly converts the boom tanker for servicing receiver aircraft equipped with probe-drogue systems.

The new adapter makes compatible the boom refueling system of the KC-97 and the forthcoming KC-135 jet tankers with such Air Force fighters as F-100, F-101, and F-105.

After removing the normal boom end the adapter is quickly fitted in its place with the hose and drogue trailing from the boom. The receiver aircraft then makes connection in a normal manner.

This is only one in a series of cooperative developments by Schulz and Wright Air Development Center that contribute to the greater efficiency and performance of the Air Force

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No. 22
June 3, 1957

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Research Is Lifeblood of Aviation

Research is the lifeblood of the aviation industry. Without a constant flow of nourishing new technical data being pumped into industry from its researchers, the vast machinery of the nation's largest single manufacturing industry would soon grind to a halt.

No other industry, with the possible exception of nuclear energy development, is more dependent on swift, sure technical progress for its future than aviation. No other industry has raced through its technical spectrum so fast during the past 50 years.

Since the first piloted flight of the Wright brothers in 1903, the aviation industry has been astride galloping technology of an unprecedented pace. Consider the fact that only 54 years after the Wrights' fabric, spruce and wire biplane lifted off North Carolina sand dunes using a 12 hp. engine and handcarved wooden propellers, man flew faster than 2,100 mph. and reached an altitude of 126,000 ft.

MULTIBILLION DOLLAR EFFORT

TO SUPPORT THIS TERRIFIC pace of technology, the aviation industry and agencies of the federal government have built a vast foundation of skilled technicians and modern research facilities. Research and development in aeronautics and its supporting sciences has grown to a multibillion dollar annual effort and shows no signs of stopping its phenomenal growth.

The aircraft industry today is ploughing 13% of its sales dollar back into research and development—the highest ratio of any major U. S. industry. This vast research and development effort embraces the resources of Air Force, Navy and Army, the vast industrial complex of the nation's largest single manufacturing industry, plus the skills and laboratories of the university system.

During the past few years the character, scope and problems of this research and development have been changing radically. Purpose of this Special Research and Development Edition, prepared by AVIATION WEEK's staff of engineers, pilots and aviation experts, is to chart the growth of this program, map the significant trends in its organization and character, and to provide a guide to its facilities and how its business is conducted within the framework of expansion.

GUIDE TO AIRPOWER'S FUTURE

LIKE PREVIOUS AVIATION WEEK special documentary reports on Air Research and Development Command and Air Materiel Command, this issue is intended to see long service as a useful business tool for the technicians and managers of the aviation industry—to provide them with a guide to airpower's technicial future.

Research and development programs devoted to aviation and its related sciences face many acute problems in fulfilling their basic function of laying a sound technical foundation for future development of the industry. Perhaps most acute is the need for continued expansion at the rate required to fully exploit the many new technical areas opened as a result of earlier research.

The history of aeronautical research and development has been marked by periods of forced draft, crisis operations followed by lengthy doldrums, where public interest lags and dollar support dwindles to an insignificant trickle. This lesson of feast and famine now appears to have been learned. Since the outbreak of the Korean War it has been possible to keep a fairly stable flow of money and technical skills into the research and development program. But the rapidly increased pace of technological development generated by the high level of research and development activity has created new budgetary problems and given rise to the "constant-level" research budget fallacy.

Research and development by their nature are dynamic progressive processes and do not fit snugly under an artificially imposed budget ceiling. Each major technical area opened by basic research creates a whole new family of problems that must be solved if fruits of a major technological breakthrough are to be harvested efficiently. In addition research and development effort constantly provides technology that enables industry to create new products for both civil economy and military use.

In place of the fallacious "constant budget level" policy that now dominates government controllers of research and development programs, a more realistic fiscal approach is required, geared to the creative character of research effort and full recognition of the effects of dollar inflation on the absolute scale of research results.

There is considerable controversy over just how

large a role the Defense Department should play in the aeronautical research program. Historically, Defense Department top level civilian managers have had only a dim concept of the value and proper role of basic research in both military and civil industrial picture. They have tended to place heavy emphasis on applied results made possible by basic exploratory research without understanding too clearly where and how this data originates.

Such organizations as the National Advisory Committee for Aeronautics, Office of Naval Research and Air Research and Development Command that have responsibility for operating research in aeronautical sciences, encounter heavy pressure from top level defense officials to bend their effort more toward development and away from basic research.

There also is some feeling in industrial research circles that the Pentagon is not the proper place for the direction of the basic research program. These research managers feel that basic research would thrive better under a more scientifically weighted organization such as a revived and invigorated National Science Foundation.

There also is a strong trend in industry to devote more of its effort to basic research in specific fields rather than to concentrate solely on product development.

NEW FACILITIES REQUIRED

THE RAPID PACE OF TECHNICAL development also has produced an acute need for new types of research development facilities. Among new kinds of facilities now required are hypersonic wind tunnels, pressure and altitude engine test cells, solar furnaces, nuclear material testing reactors, supersonic sled tracks and captive missile test stands.

Neither planning nor implementation of major government research and development facility construction programs have kept pace with these requirements. Demand for hypersonic and missile re-entry data already was acute before shock tube and multi-stage missile test vehicles were available to produce it. Demand for new types of development test facilities also has outstripped the ability of industry and government to provide them in time. Such new hardware items as ramjet engines, rocket engines, exotic fuels and ballistic missiles were ready for experimental testing before adequate test facilities were designed, built and properly instrumented to handle them.

Basically, government philosophy has been to confine its research and development facility investment to projects too costly for industry to build or operate as individual firms. Good examples of this are the huge NACA installations at Langley, Ames and Lewis Laboratories; USAF Missile Test Center at Cape Canaveral, Fla., with its 5,000 mile instrumented range stretching through the Carribbean to the South Atlantic, and the Arnold Engineering Development Center at Tullahoma, Tenn. Government also made development test facilities available for 40 industry contractors through Unitary Plan wind tunnels.

GOVERNMENT FACILITIES

BUT INDUSTRY has found that using government development facilities, particularly for early experimental work, exacts too heavy a time penalty in the stiff competitive race for hardware contracts. As a result most successful firms have invested heavily in their own development facilities. Virtually every major airframe contractor has his own supersonic wind tunnels. All major engine manufacturers such as General Electric, Pratt & Whitney and Allison, have built large jet engine development laboratories. Bell Aircraft Corp. now is building the Lawrence Bell Research Center, covering research in hypersonics, aerodynamic heating, nuclear development and helicopters.

University facilities are playing an increasingly important role in both research and development. Examples are the Lincoln Laboratory operated by Massachusetts Institute of Technology for the SAGE program, Cornell Aeronautical Laboratory and the Jet Propulsion Laboratory at CalTech.

Although the government now is spending over a billion dollars annually for research and development activity—about 60% of it with industry—there is a strong trend to get industry to shoulder a higher percentage of overall research and development requirements with its own money. Because of competitive reasons industry would prefer this type of operation, but before it can be effective there must be basic revisions of government cost regulations in this field.

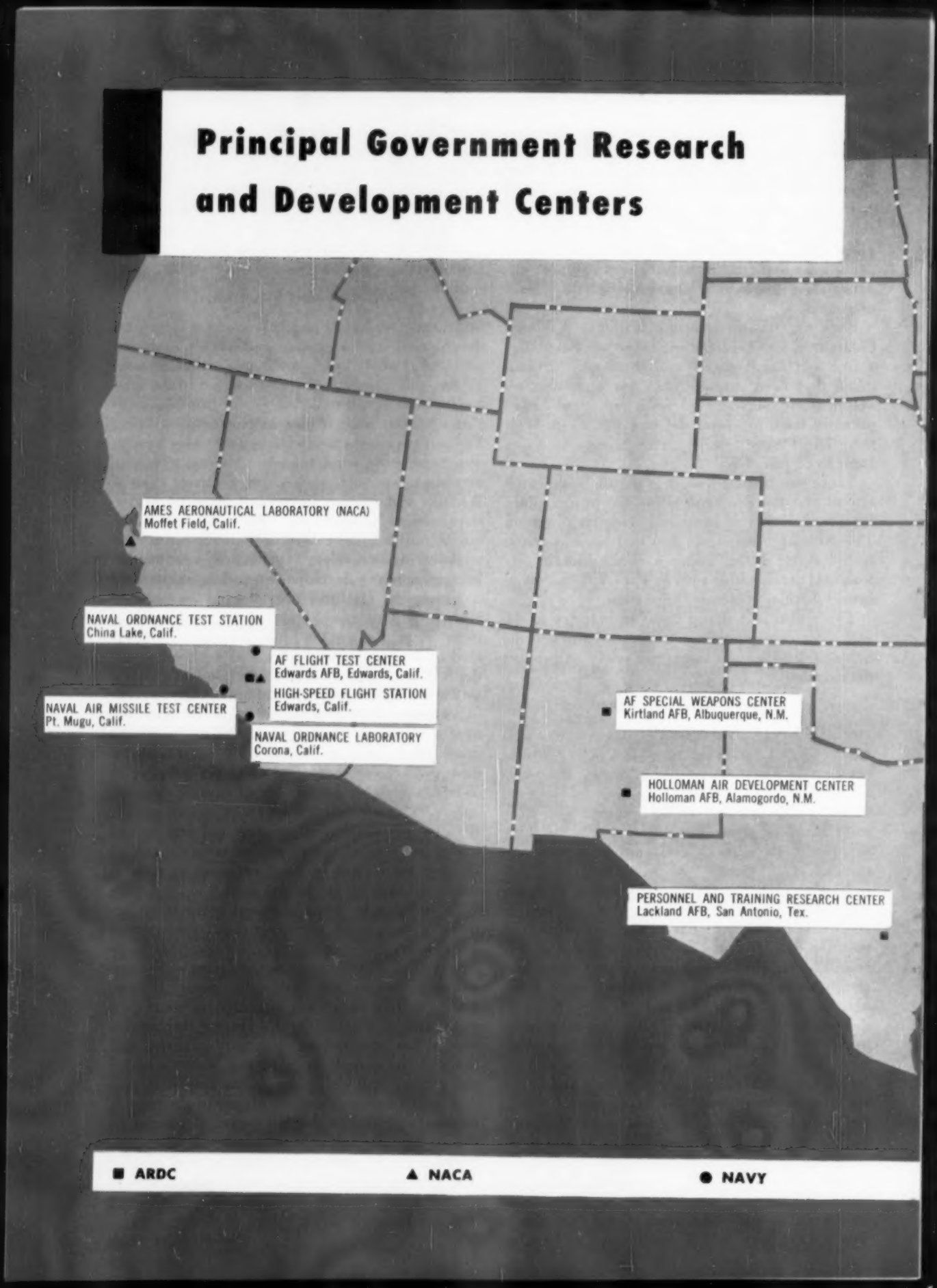
In addition to fierce technical competition between U. S. military services and private industry for military and commercial business, total U. S. technical effort in aeronautics is facing stiff international competition from the Soviet Union. Russia entered the atomic-airpower technical race at the end of World War II. During the last decade it has demonstrated a rate of progress that shocked the complacency of the Western world and poses a stiff challenge for the future.

A sound research and development program is necessary to realize the full potential offered by the air age. Its cost will be relatively small compared with the national security it will provide and billions of dollars in new products it will create. But it will be one of soundest investments that can be made in the future of this country.

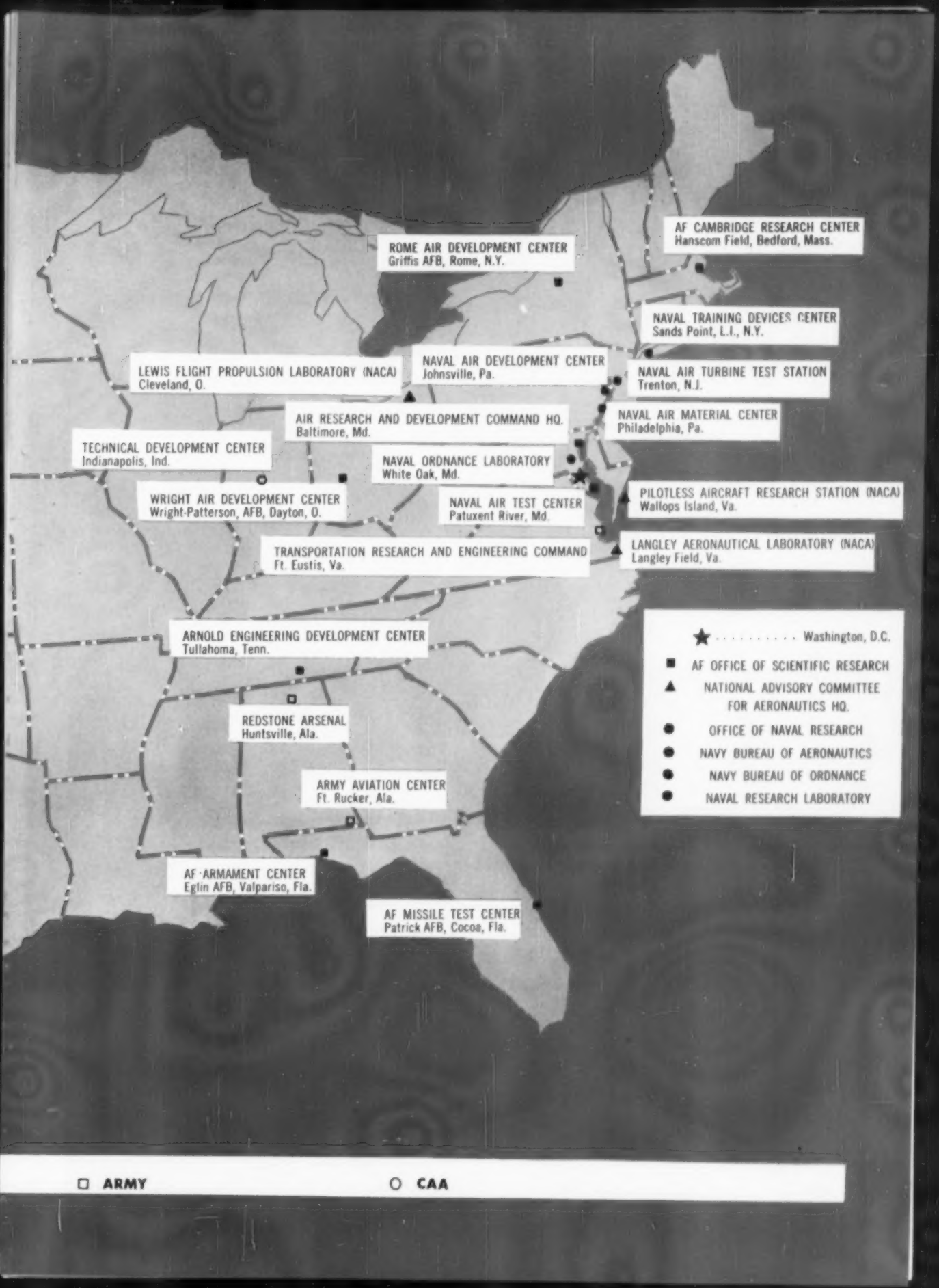
—Robert Hotz

of this program, map the significant trends in its

There is considerable controversy over just how



—Robert Hotz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AF CAMBRIDGE RESEARCH CENTER
Hanscom Field, Bedford, Mass.
NAVAL TRAINING DEVICES CENTER
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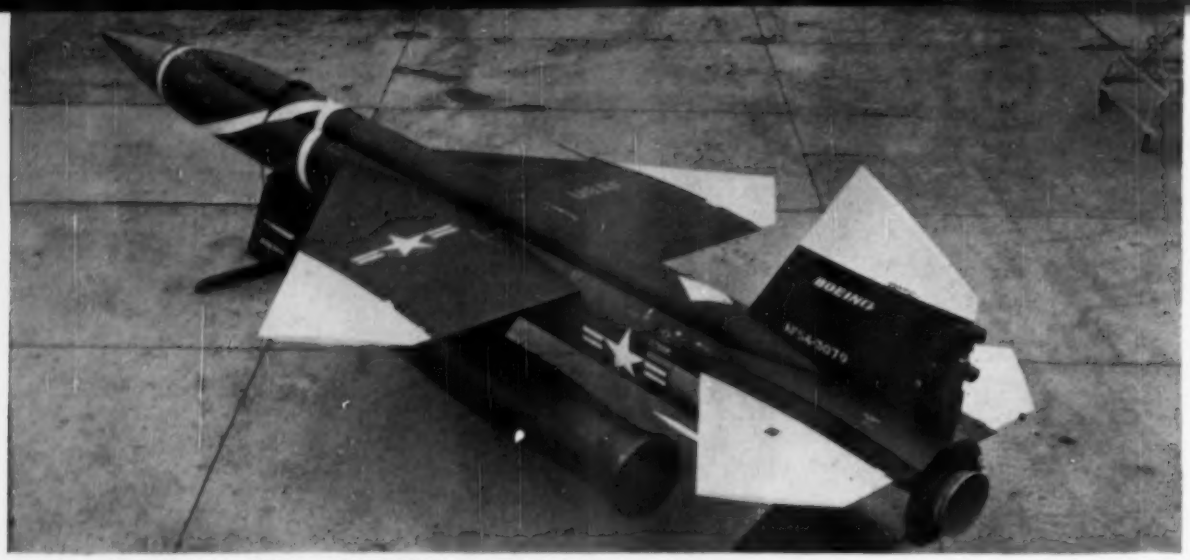
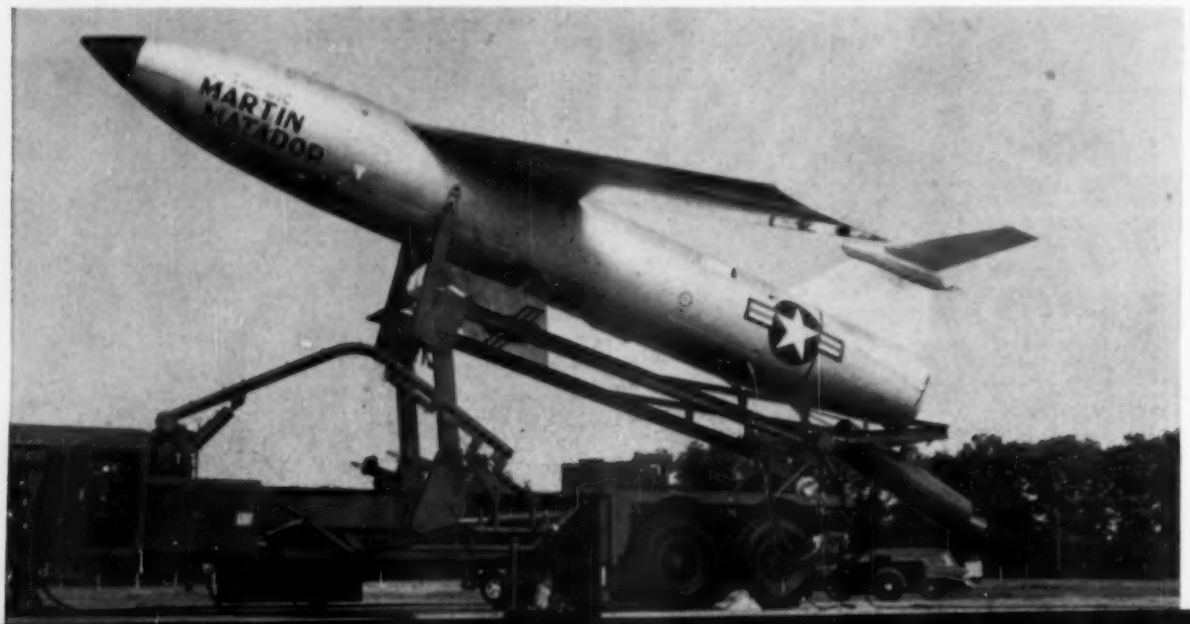


BOMARC, unveiled on Armed Forces Day at Andrews AFB, Md., has two ramjets, sustainer rocket, and wing-tip control surfaces.

Services Give Public Missile Close-Up

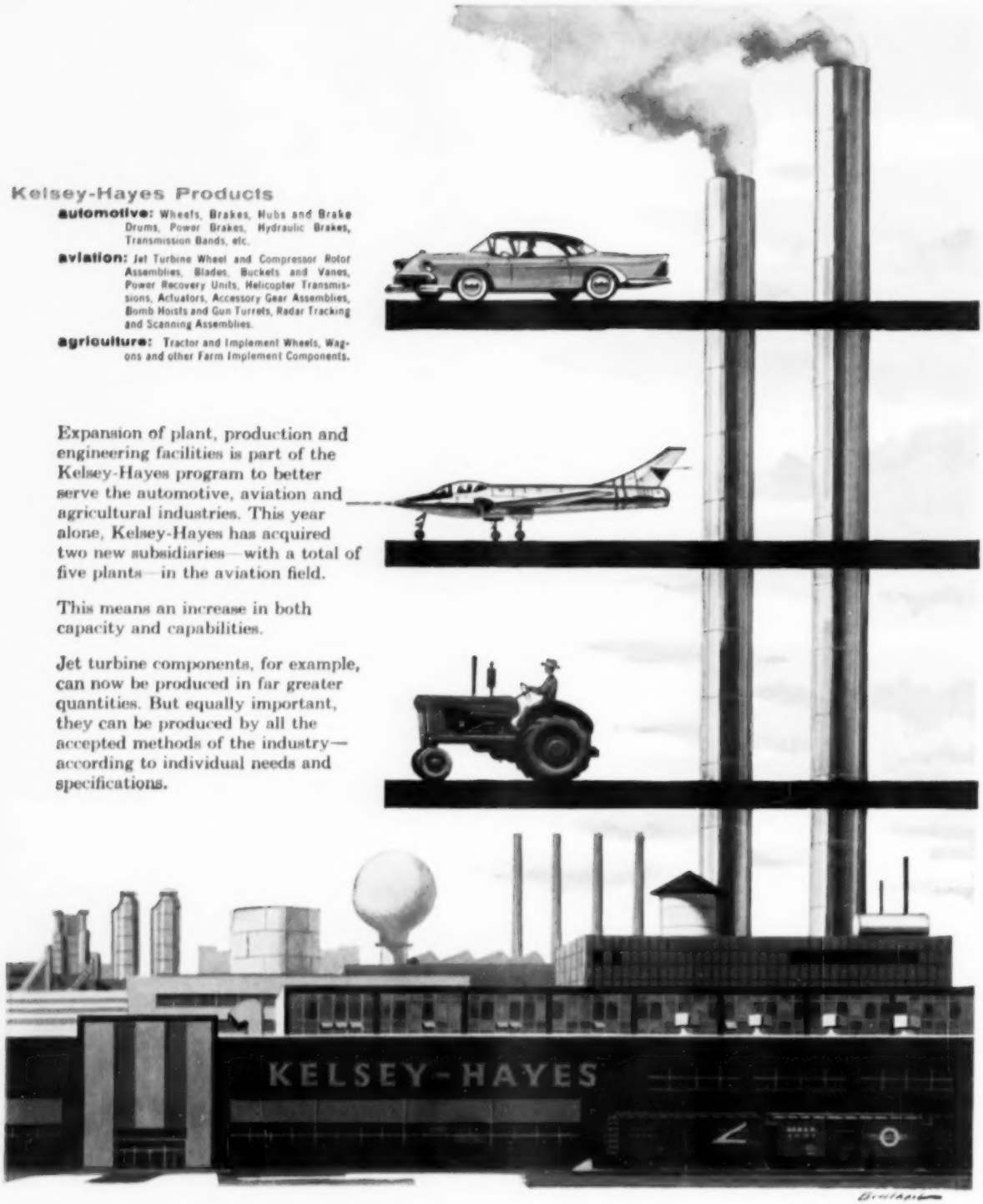
LACROSSE surface-to-surface Army missile, above, and newest USAF Matador, the TM-61C, were displayed on carrier-launchers.



CONICAL CAMBER research model in NACA tunnel at Ames Aeronautical Laboratory, Moffett Field, Calif.

NACA

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS



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automotive: Wheels, Brakes, Hubs and Brake Drums, Power Brakes, Hydraulic Brakes, Transmission Bands, etc.

aviation: Jet Turbine Wheel and Compressor Rotor Assemblies, Blades, Buckets and Vanes, Power Recovery Units, Helicopter Transmissions, Actuators, Accessory Gear Assemblies, Bomb Hoists and Gun Turrets, Radar Tracking and Scanning Assemblies.

agriculture: Tractor and Implement Wheels, Wagons and other Farm Implement Components.

Expansion of plant, production and engineering facilities is part of the Kelsey-Hayes program to better serve the automotive, aviation and agricultural industries. This year alone, Kelsey-Hayes has acquired two new subsidiaries—with a total of five plants—in the aviation field.

This means an increase in both capacity and capabilities.

Jet turbine components, for example, can now be produced in far greater quantities. But equally important, they can be produced by all the accepted methods of the industry—according to individual needs and specifications.

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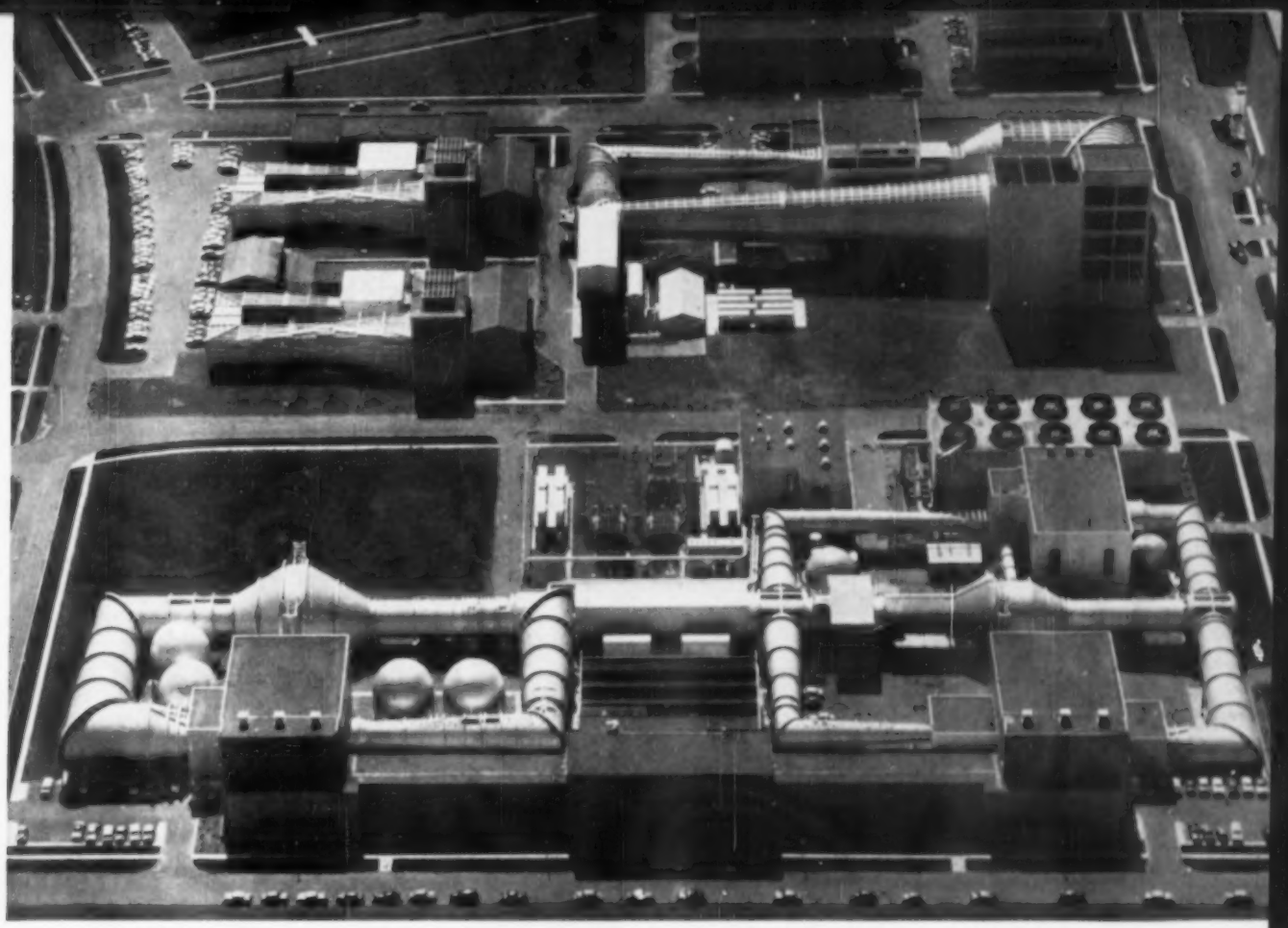


FIRST AERIAL PHOTO of Unitary Plan three-tunnel group at Ames Aeronautical Laboratory. Mach range is .7 to 3.5.

Ames Probes Hypersonic Flight Region

By Richard Sweeney

Moffett Field, Calif.—Aerodynamic research to gather knowledge on which designers of future hypersonic aircraft can draw is the prime mission of National Advisory Committee for Aeronautics' Ames Aeronautical Laboratory.

Basic tools are 19 wind tunnels, a number of aircraft modified to the laboratory's special purposes, flight data-gathering and assessment equipment, and the computing and other facilities necessary to carry aerodynamics from the theory stage through wind tunnel and flight test evaluation.

In addition to its basic research mission, Ames helps on specific airplanes through its Unitary plan wind tunnel, in which contractors can do developmental testing of new aircraft. NACA furnishes facilities and tunnel operating personnel and contractors handle other aspects.

High-Speed Facilities

Currently, deepest probing is into hypersonics—flight at Mach 5 and above—since a great deal of information is needed for the ballistic missile program. Subsonics and transonics still get attention since high performance aircraft must land and take off on reasonable lengths of concrete and pass through Mach 1 with as small a thrust requirement as possible to overcome drag.

Facilities used primarily in very high-speed research include:

- **Light gas gun,** capable of firing quarter-inch models at speeds approaching 16,000 mph.
- **The 10 by 14-in. hypersonic tunnel,** capable of Mach 6.3.
- **Supersonic free flight tunnel,** capable of up to Mach 3, with a test section 18 by 18-in. and 28-ft. long. Models are fired from guns to achieve even higher Mach numbers in certain tests.
- **The 18-in. low density tunnel,** which can reproduce Mach 6 at densities equivalent to altitudes above 100,000 ft.
- **The 10-in. heat transfer tunnel.** Stainless steel nozzle enables this tunnel to sustain entrance temperatures of 1,200F. Model recovery air temperature also stays high in stainless steel test section. Velocity is up to Mach 6.
- **A 6-in. heat transfer tunnel.**

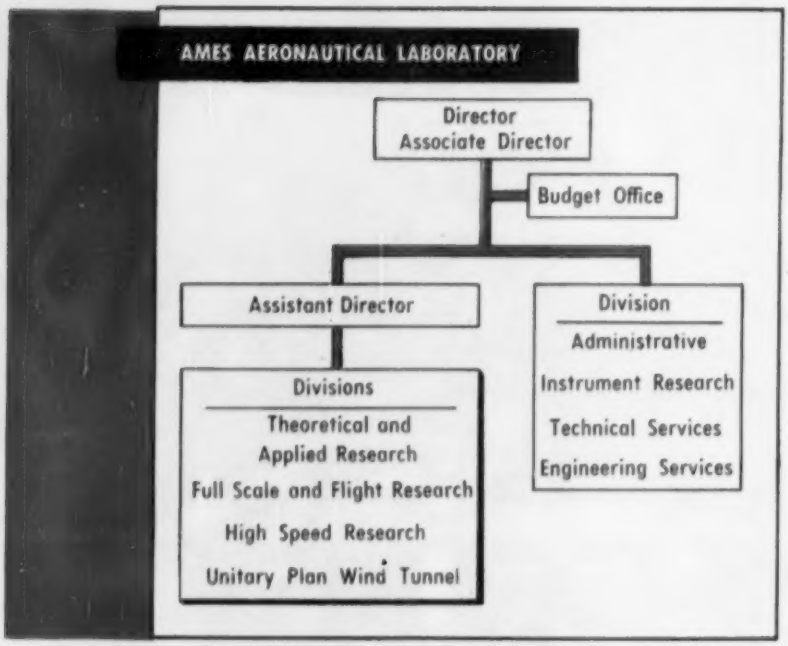
Ames has under construction a new light gas gun much larger than the small developmental model currently in use. New facility will enable ¾-in. models to be fired longer distances at speeds up to 16,000 mph.

In the future, Ames may mount the small light gas gun in wind tunnels to get higher Mach numbers and longer model travel distances.

Lower-Speed Facilities

Subsonic and transonic research is conducted in these tunnels:

- **A 6 by 6-ft. transonic and supersonic** facility, which uses a slotted throat for transonic tests and a sliding block nozzle for work somewhat above Mach 1.



• **A 14 by 14-ft. slotted throat transonic unit.**

• **Unitary three-tunnel group** (AW July 15, '55, p. 15), with velocities ranging from Mach .7 to 3.5 according to which tunnel is used. The 6 by 6, 14 by 14 and Unitary tunnels all are hooked into automatic data reduction installations so that, as tests are being run, raw data is pumped continuously from tunnel control center through converting equipment, into a digital computer, and returned to the control center as computed data presented in line-plots and non-dimensional coefficients.

• **The 40 by 80-ft. full-scale tunnel,** capable of speeds up to 250 mph.

• **The 12-ft. pressure tunnel,** where the variable density characteristic can produce up to six atmospheres and yield high Reynolds numbers.

• **Two 1 by 3-ft. supersonic tunnels,** one a blowdown type, the other steady flow. The blowdown tunnel is the oldest supersonic facility in the U. S., dating from 1945.

• **A 2 by 2-ft. transonic tunnel** used in basic airplane research.

• **An 8 by 8-ft. tunnel** used primarily as a wind tunnel design tool.

• **Two 7 by 10-ft. subsonic units** dating from 1940-41.

• **A 1 by 3½-ft. tunnel,** barely transonic, largely out of use.

Ames seeks widest tunnel utilization with minimum expenditure. Illustrating this are current studies involving helium used in existing tunnels for certain work, whether it is practical to modify the tunnels to recapture the scarce gas for reuse without extensive and expensive rework, the intricacies involved in designing helium capability into future tunnels.

The laboratory has requested funds for a new "hot" tunnel with a 3½-ft. test section and Mach 10 velocity, capable of operating for seconds instead of the micro-seconds now possible in the 10 by 14-in. hypersonic tunnel. Design of the unit envisions a combination of heat resistant materials and tunnel cooling rather than a single approach to solution of the heating problem.

In the tunnel itself, investigators would take on temperature, Mach number and scale effect one at a time rather than attempt to get all three aspects at once in a brute force attack.

Current subsonic investigations center in helicopters and in short and vertical takeoff and landing, fixed-wing aircraft. Boundary layer control also is studied.

A principal tool in this work is the full-scale tunnel, where helicopter rotor systems, various boundary layer control systems, and the various systems for obtaining short or vertical takeoff and landing characteristics on fixed-wing aircraft can be thoroughly investigated.

Human Aspects Considered

Flight test is complementary to wind tunnel work at Ames. In flight, the human aspects of aerodynamics also come in for close inspection.

In a typical case, a design theory may be in the making, with certain characteristics of stability and control. The laboratory will work through the theoretical areas, progress to simulation on the analog, then try out the results on the variable stability airplanes (AW Aug. 1, '55, p. 25).

Information is sought on the degree of instability or unpleasant handling characteristics a pilot can live with; how long he can function with them, and what other effects on the pilot result from flying an aircraft which may compromise desirable characteristics severely in order to get exceptional performance capabilities.

Human aspects are very necessary parts of the overall picture, Ames believes. If the human element can function longer under worse conditions than previously thought, gains may be possible in performance, weight and reduced systems complexity.

In reverse, if the human element should be called on to function too long under conditions in which human capabilities may be impaired without the pilot's realizing it, acute danger might not exist, but a critical mission might fail.

Flight Testing Basic Ideas

Another facet of Ames flight test work is in-flight testing of new basic ideas. In the case of a boundary layer control system, for example, the laboratory will conceive a theory, proceed through the logical steps prior to flight test, then develop hardware suitable to reproduce the desired conditions only.

No attempt is made to produce finished mechanisms with full attention to weight, complexity and serviceability. This part is left to contractors.

Tests are related to aerodynamic performance of the idea being investigated. When they are completed, reports are published for the industry to use as basic guides in development of their own particular designs in that field.

The laboratory also works in the aerodynamics of fire control-autopilot systems. Investigations are concerned with the relationship of aerodynamic stability and control characteristics as they affect the fire control portion of the entire airplane-weapon system loop. Research in this field gains added importance as speeds of aircraft, delivering still faster ordnance against aerial and ground targets, increase.

This is especially true as planes enter that part of the speed spectrum where stability appears sufficient to the pilot, while the true condition is critical enough that any change in aircraft movement or configuration may result in a divergence violent enough to destroy plane and pilot.

In its investigations, Ames does no structures work, but does pick up information on loads which often proves helpful to other NACA laboratories.

For flight test work, Ames now has an F6F-3 and F-86A variable stability test beds, plus F-100s and F-86s reworked

for special investigations. Ames gets aircraft from the services after they have reached operational status, and it hopes soon to add an F-102A and F-104B to its aircraft complement.

Performing the mission at Ames are the following divisions:

- **High Speed Research.**
- **Full Scale and Flight Research.**
- **Theoretical and Applied Research.**
- **Instrument Research.**
- **Technical Services.**
- **Unitary Plan Wind Tunnel.**
- **Engineering Services.**
- **Administrative.**

Each division has branches dealing with the various phases of its particular specialty. Each wind tunnel is assigned to a specific division according to the tunnel's primary use.

Following the pattern of NACA laboratories, Ames is a self-sustaining entity, completely equipped to support its mission. There are facilities for all aircraft repairs, maintenance and modification. Instrumentation can be reworked, redesigned and rebuilt, and when time or peculiarity of application dictates, new instrumentation can be produced from conception through flight hardware.

Director of the $66 million, 100-acre laboratory is Smith J. DeFrance. Associate director is John Parsons.

$12.8 Million Budget

Ames was allocated $12.8 million for salaries and expenses during Fiscal 1957, indicating the scope of the research effort. This does not include funds for construction of new facilities, such as the light-gas gun now being built.

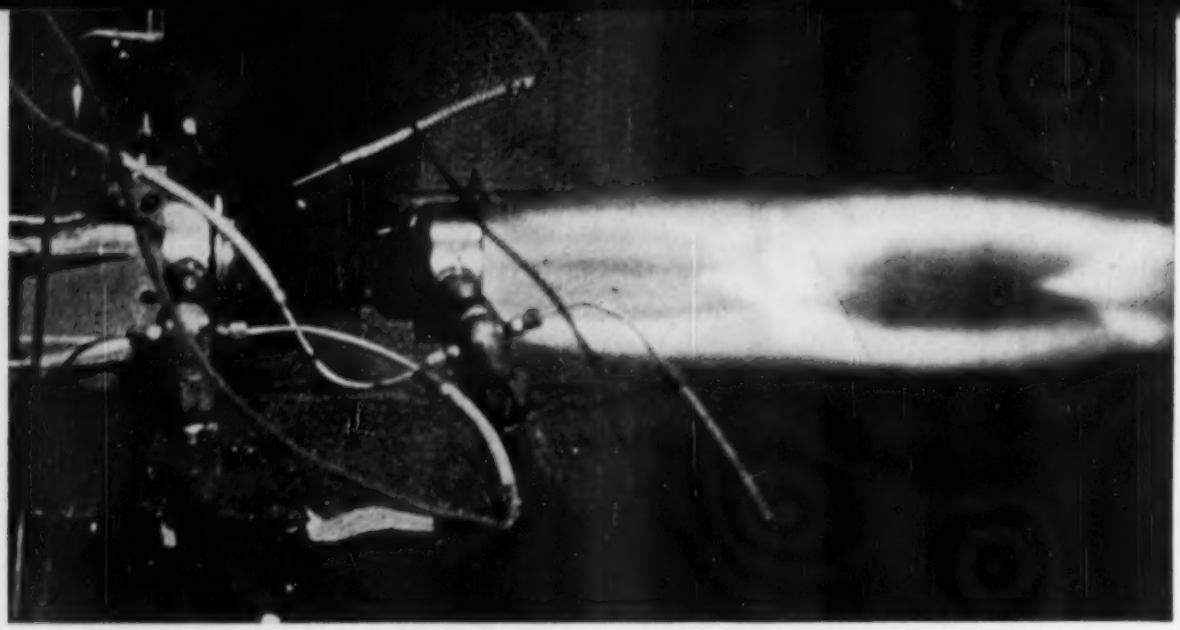
No official record has been kept of exact wind tunnel running time, but many of the Ames facilities can be operated simultaneously. One exception is that the 182,000 hp. unitary tunnel and the 110,000 hp. 14-ft. transonic tunnel cannot operate at the same time.

The laboratory draws its large requirement of electric power from the Bureau of Reclamation's Shasta Dam and Pacific Gas & Electric Co., so that at no time does its operation sap civilian power sources enough to cause trouble.

Flight time at the station averages between 700 and 800 hr. per year of research operations.

Current personnel strength is 1,420, including 334 research scientists, 67 engineers, 14 mathematicians, 6 pilots, 23 aerodynamic test technicians, 72 computation specialists, 30 draftsmen, 126 machinists and toolmakers, 50 electricians, 50 aircraft mechanics, 22 aviation metalsmiths, 96 instrument makers, 104 wind tunnel mechanics, 16 photographers, 144 clerical personnel, 20 administrative specialists, plus some 250 miscellaneous positions. ■

AMES UNITARY tunnel's 11-stage compressor, above, can generate a Mach 3.5 airstream through 8 by 8 ft. test section. Below, model in 14-ft. transonic tunnel.



FLAME PRODUCED by 1,000-lb. thrust, fluorine-ammonia rocket engine in test cell at NACA's Lewis Flight Propulsion Laboratory.

Lewis Pushes Work on Rocket Engines

By Robert Cushman

Cleveland—Expansion of rocket engine development, increased evaluations of high-energy fuels, and smooth productive operation of the new 10 by 10 supersonic Unitary propulsion wind tunnel highlight the research efforts of the National Advisory Committee for Aeronautics' Lewis Flight Propulsion Laboratory.

This year propulsion emphasis at Lewis will be on bringing the status of non-air-breathing rocket engines up to that of their air-breathing cousins, the turbojets and ramjets.

When the new rocket test facility opens in the Lewis "South 40" area this year it will provide a significant jump over the present rocket facilities, which do not compare in size and scope of detail to Lewis' elaborate air-breathing engine facilities.

About one-fourth of the 500-600 professionals in the 2,700-man Lewis complement are working on rocket development.

The largest group is working on problems of air-breathing engines and will be for the foreseeable future.

High-Energy Fuels

The new 20,000 lb. thrust rocket facilities will be used to continue the work Lewis is doing on high specific impulse propellant combinations. High-energy propellants are those with specific impulses of about 300 seconds.

Meanwhile, Lewis is not neglecting its pioneering interests in high-energy fuel mixtures for air-breathing engines. One of the first uses for the new 10 by 10 ft. propulsion wind tunnel last year was a simulated flight evaluation of exotic light metal, slurry-type fuels burning in a ramjet.

Along with the high-energy chemical fuels, Lewis also is studying the highest-energy fuel known—nuclear fuel. In the Materials and Stresses building, equipped with its own cyclotron, Lewis scientists are studying the propulsion cycle and shielding problems which at present bar successful application of nuclear power to aircraft.

Lewis' approach to these elusive problems has been to try to gain a fundamental insight into the solid state make-up of materials.

Knowledge that comes from these investigations will be useful to all phases of propulsion.

That Lewis' nuclear propulsion efforts are not larger is typical of the way NACA uses the funds allotted by Congress. Since nuclear propulsion is now where rocket propulsion was 10 years ago, NACA's investigations are modest. As creative knowledge increases and the advent of practical nuclear propulsion draws nearer, NACA efforts in this direction are expected to accelerate. One indication of things to come is NACA's new Plum Brook Research Reactor Facility, now building near Sandusky, Ohio.

High-energy fuels extract a price. In rockets, the propellants are difficult to handle and the rocket exhaust products are poisonous. In the case of exotic fuels for air-breathers the metallic slurries leave deposits on and corrode the blades of turbines and combustion chambers, and may have to be limited to afterburners and ramjets. The penalties of radiation and poisonous waste products in nuclear propulsion systems are well known.

The rocket section of the Lewis laboratory has been making studies of types of vehicles that might use some of the high-energy propellants. They have attempted to analyze weapons systems that might be evolved to live with the handling and operational hazards.

Use of hydrogen-flourine, for example, would entail:

- **Toxic boil-off** of products from the liquid fluorine being loaded into a missile before launching.
- **Poisonous cloud** of hydrogen-fluorine gas from the rocket exhaust at launch.
- **Corrosive action** of the chemicals on the missile tanks, feed lines and pumps during all phases.

Possible Solutions

The first problem could be solved either by refrigerating the oxidant tank in the missile to minimize boil-off and avoid the necessity for venting, or the vented products could be piped to another tank where they would be reconverted into liquid.

Just before firing, the external means to check the boil-off would be removed and the tank closed off, as is now done with liquid oxygen, and the boil-off vapor contained by the structural design of the tank.

The second problem could be of larger magnitude. Because of the toxic

nature of the hydrogen-fluorine exhaust gases, means would have to be provided to protect personnel in the launching area from the 10-100 ft. cloud concentration that would be poured out by the missile before it picked up speed.

Obviously, this could be solved by remote launching sites. But it is more likely that hydrogen-fluorine will be used only for second or third sustainer stages. Even in this limited use, the high-energy propellent would yield very significant gains in overall performance. Not only would it increase the range of the latter stages but it would markedly decrease the weight that the first stage had to boost.

Complications Are Doubled

Some of the practical problems in using high-energy, fluorine-type oxidizers can be appreciated by observing the 200-lb. tests stands now being operated at Lewis.

Fluorine oxidizer supply tank and feed lines must be submerged in an insulated trough containing a refrigerating bath of liquid nitrogen. But it is on the larger 5,000 lb. test stand—also in operation at Lewis now—that a prologue of the problems awaiting ICBM-sized rockets using these fuels can be seen.

On ordinary tests stands, using lox and ammonia or jet fuel, all that is needed are nitrogen pressurized tanks of the oxidizer and fuel with piping and valving to carry these in properly metered amounts to the rocket chamber. On high energy test stands the number of handling complications and safety precautions are more than doubled.

First, for safety in case of a major malfunction, the fuel must be kept outside the test house, physically separated from the oxidizer by a concrete wall or moat. The oxidizer is completely submerged in a nitrogen refrigeration bath. Care must be taken that no boil-off products leak to contaminate the test area.

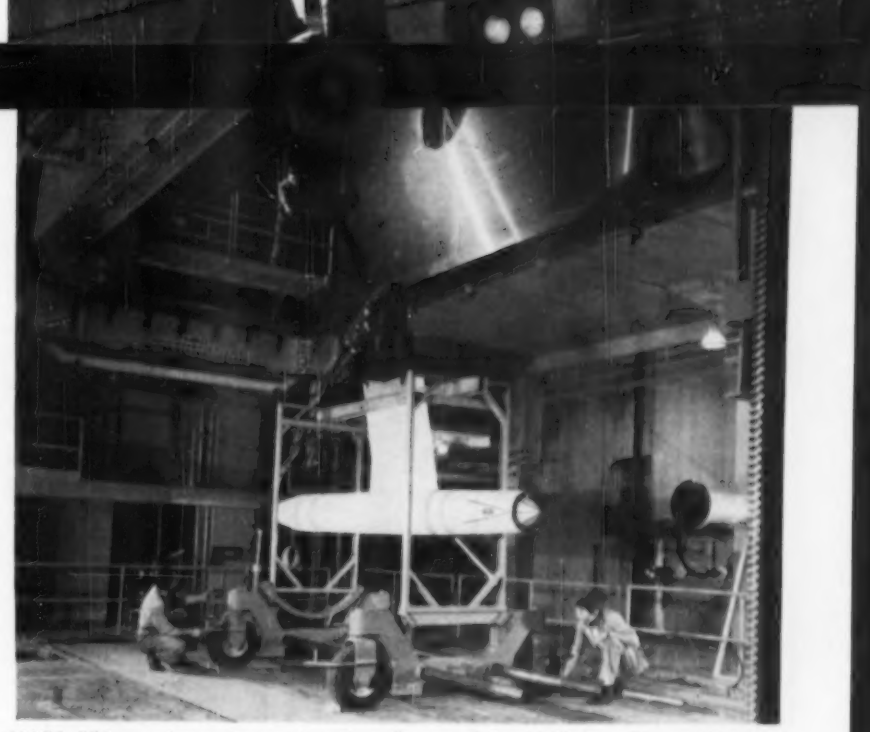
As a warning device, Lewis wraps an electrical conductor around all the lines so that if a leak does occur the natural action of the oxidizer will burn the insulation and short the warning circuit.

In operation the fluorine-type oxidizer is fed into the 3-ft. diameter pressurizing bottle as a gas and the bottle is then lowered into the nitrogen to liquify the fluorine. Once the oxidizer is liquified, helium is piped in for pressurization.

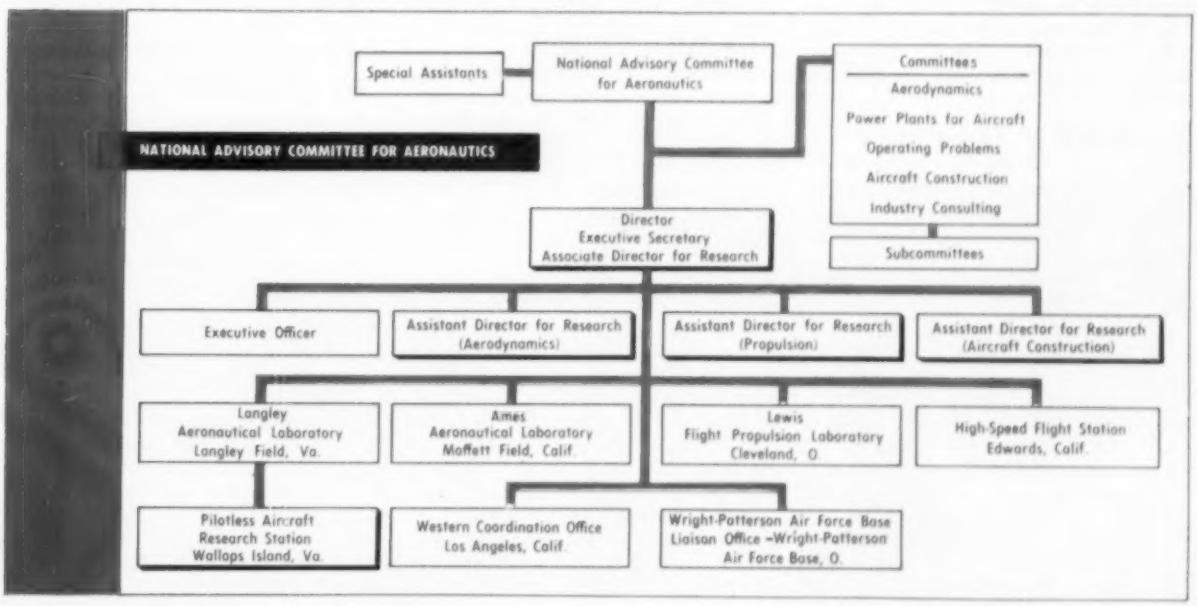
Test runs seldom exceed 30 seconds because of the cost of the high-energy propellants. In the 5,000 lb. thrust stand, for example, the $5-20 per lb. oxidizer is consumed at the rate of 15 lbs. per sec. This can send the cost of a 30 sec. test firing up to $5,000, not including the cost of the 5 lb. per sec. fuel flow.

Unlike many rocket test stands which have been pictured, the Lewis high-energy stands can not simply permit the exhaust to go out into the atmosphere.

In addition to silencing the exhaust, poisonous fumes must be removed. For the first reason the exhaust system looks



NACA 16-in. ramjet on test section floor elevator of Lewis' Unitary Plan wind tunnel. Inclined strut hangs model from tunnel ceiling, houses data-sensing conductors.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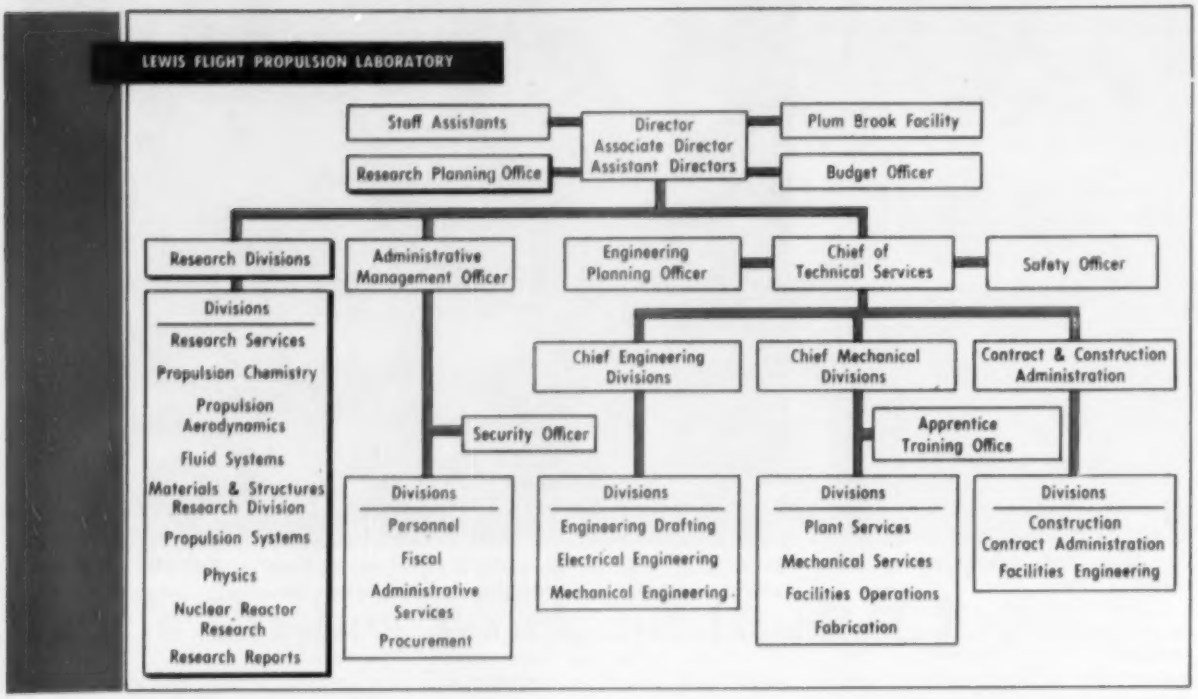


more like a turbojet test stand, with a horizontal ejector tunnel about 40 ft. long and some 5 ft. in diameter leading into a vertical stack.

Water is sprayed into the rocket exhaust jet where it enters the ejector duct, but the water performs the vital function of absorbing the poisonous gases, which go into solution in the water.

More water is sprayed in as the exhaust goes up the vertical exhaust stack at the end of the ejector. Here the gases are thoroughly "scrubbed" so that all of the hydrogen-fluorine gases are dissolved in the water, after which they drop to the sump at the bottom of the tank. The hydrogen-fluorine collected here is neutralized with lime and pumped into sewers.

New 20,000 lb. Thrust Stands

The larger 20,000 lb. high-energy propellant facilities at the "South 40" location will permit an even closer approximation of the full-scale problems of handling these dangerous chemicals. In addition the larger scale of the rockets to be used will serve as a further check on the scale effect, which is just as important in rockets as in turbojets.

The doubled size of the 20,000 lb. thrust rockets will permit more sophisticated structural designs. Lewis will be able to experiment with chambers and nozzles made up of bundles of cooling tubes.

It has been about a year since Lewis' part in the Unitary program—the large 10 by 10 ft. supersonic tunnel—first went to work. In the first year, at the rate of about one project a month, the tunnel produced invaluable flight simulation data.

It has given insights practically unobtainable otherwise on a variety of projects including the in-flight performance of one of the B-58 bomber propulsion pods, complete with variable inlet and burning J79 engine; performance boost to be expected from high-energy and exotic fuels burning in NACA ramjets; and stamina of a 2 ft. diameter nylon pilot parachute, opened into a Mach 2.0 airstream.

It is significant that all these runs had to be accomplished at more than the Mach 2.0 and 50,000 ft. lower limits for the 10 by 10. The fact that the upper limits of the tunnel, which was conceived in 1949-1950, are Mach 3.5 and 160,000 ft. altitude, indicates the caliber of progress that it has been intended to guide and foster.

The lower limits were set by a desire to have the 10 by 10 take over where the 6 by 8 tunnel left off.

Problems Mainly Routine

Carl F. Schueller, chief of the 10 by 10, said that outside of routine breaking-in problems like bearing misalignment due to foundation settling, and the usual control problems, the only unexpected incident was a crack in the bellmouth wall shell plating.

This occurred last winter on a day when the temperature was seven degrees below zero and the tunnel was running with a burning ramjet engine at its maximum Mach number of 3.5.

Although the free stream air in the tunnel was −70F in accordance with the test altitude, the stagnation temperature along the inside of the wall was 300F.

The stress gradient between this and the −7F temperature outside proved to be too much and the one inch plating gave way. The rift was soon welded up and no other problems of this sort have been experienced.

Lewis Unitary Tunnel

Since the 10 by 10, in contrast to the other Lewis facilities, is a Unitary Plan tunnel, it is not so much a research tool directly for NACA's use as it is a facility operated by NACA for the convenience of the services.

On the other hand, the older 6 by 8 ft. propulsion wind tunnel, which goes up to Mach 2.0, is a full-time NACA tunnel. It is currently being re-equipped with a continuous circuit for aerodynamic tests, and is having a ventilated throat test section added to make it useful in the transonic region.

Lewis' engine research group feels it has come to the end of one phase of research and is beginning another. Much of the past emphasis on details of components is giving way to engine-as-a-whole tests.

Two altitude chambers and the altitude wind tunnel are being used for the complete tests. These facilities are old by comparison with the 10 by 10 but they serve as valuable development tools in the intermediate area between component test stands, where compressors and turbines are run separately,

TURBINE blades are tested on thermal shock apparatus at Lewis.

INLET DATA is obtained in 18 by 18 in. supersonic tunnel.

and the propulsion wind tunnels, where engines complete with nacelle fairings are slung in airstreams.

Combustion and Materials

Two development efforts which still are done on the component level are the ever present problems of finding out what the combustion process is, and learning to make high temperature engine parts.

Work on both combustion phenomena and better heat resistant materials is hampered by the same research limitation: both are too small to see.

The ideal combustion research tool would produce magnified slow motion color pictures of the behavior of the atoms and molecules, showing how the electron patterns change in the chemical process.

Similarly, the ideal tool for materials research would permit the researcher to look inside the "solid state" of the materials and see, for example, what happened to the molecules at the grain boundaries under stress.

As facilities exist only to fulfill current and future research needs they go as well as come. The best example of this at Lewis is the icing research wind tunnel.

In the past year NACA completed the bulk of its own icing research program. Because the tunnel is the largest and best of its kind, it may be kept in existence indefinitely for use in industry test work.

NACA feels that most of its basic icing research has been accomplished—mainly through use of this tunnel and analytical laboratory work—and that sufficient information exists to alleviate aircraft designers' and operators' problems. In other words, NACA believes these problems now are matters of applying principles which it and others have outlined.

Two recent icing programs dealt with effects of icing on thin fighter wings and on all-weather airships. For supersonic fighters with razor-thin 4% wings, researchers calculated that the ice build-up might occur in a very small part of a typical mission. Formation of ice on the leading edge might increase or decrease lift and drag at slow speeds, depending on the ice shape.

For Navy radar blimps that must keep station in all-weather operations, it was found that icing was no problem for small cloud droplets because the blimp's size in relationship to the icing droplets prevented build-up. For large droplets of freezing rain, however, icing could be troublesome.

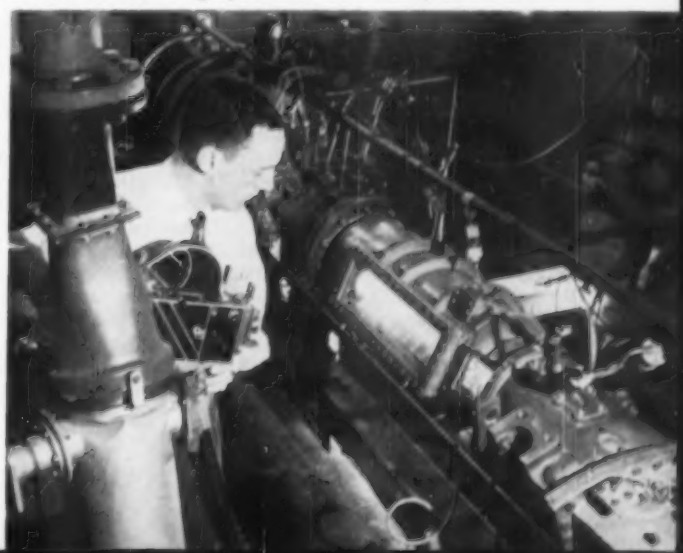
The section that had been doing icing work now has started on new projects, most of them classified.

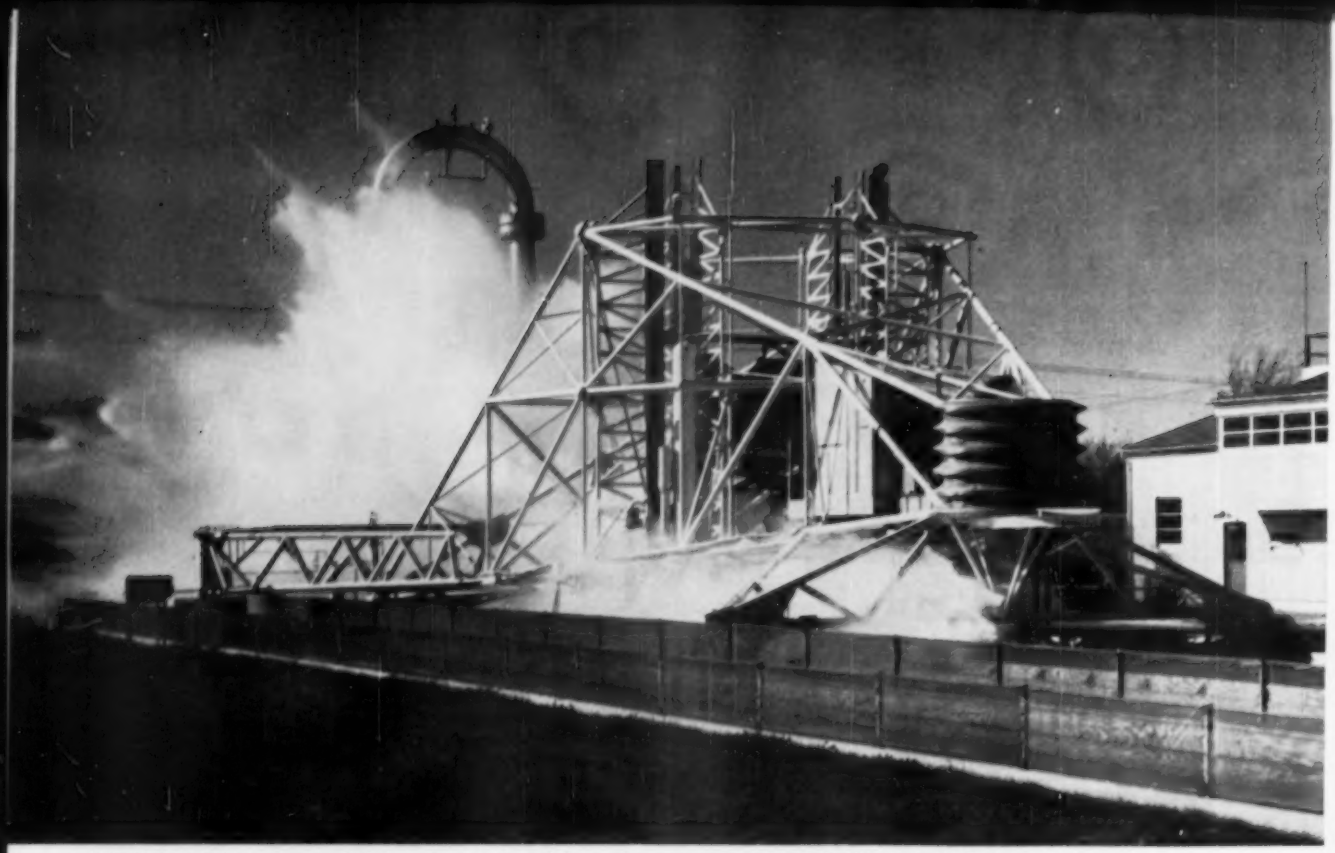
One that is not is a study of jet exhaust stream deflection by three-sided ducts.

Preliminary tests have shown that the Coanda effect can be used to bend fairly thick sheet flows. This work is similar to the British jet flap, but instead of bending thin sheets of airflow over a flap, researchers here add side-plates to bend the whole jet flow for direct lift, lateral control forces or even thrust reversal. ■

ROCKET engine test runs are monitored from control room.

COMBUSTION test rig operation is recorded by cameras.





LANDING LOADS track, propelled by water jet, is used for testing stresses on aircraft landing gear, hydrodynamic studies.

Langley Attacks Hypersonic Heating

Langley Field, Va.—Langley Aeronautical Laboratory, oldest and largest National Advisory Committee for Aeronautics installation, is pressing the search for aerodynamic and structural answers to problems of flight at speeds up to 20,000 mph. and altitudes of 100 miles.

Since heat is the overwhelming problem in the regime of extremely high-speed, high-altitude flight, it demands the bulk of the research effort.

New facilities going into service at Langley this year and planned for the near future will permit a massive attack on the scientific and engineering mysteries of aerodynamic heating at hypersonic speeds.

Langley had its beginning in 1919 as NACA's first station. It occupied 5.8 acres in tidewater Virginia, off the Chesapeake Bay, and by the time of its dedication in mid-1920, it boasted a 5 ft. wind tunnel and an engine laboratory.

It is now a $100 million plant, and the new Unitary plan wind tunnel alone covers almost four acres.

Since World War II, speeds of tactical aircraft have increased from 400 to more than 1,000 mph. Speed of research planes has gone from the subsonic region to 2,178 mph., and the newest research aircraft—the X-15—will explore heating, stability, control, and re-entry problems in the low hypersonic regions. Missiles nearing test will reach velocities of 18,000 mph. and tremendous temperatures.

New Hypersonic Facilities

To meet this challenge of hypersonic flight, Langley is asking for these new facilities in Fiscal 1958:

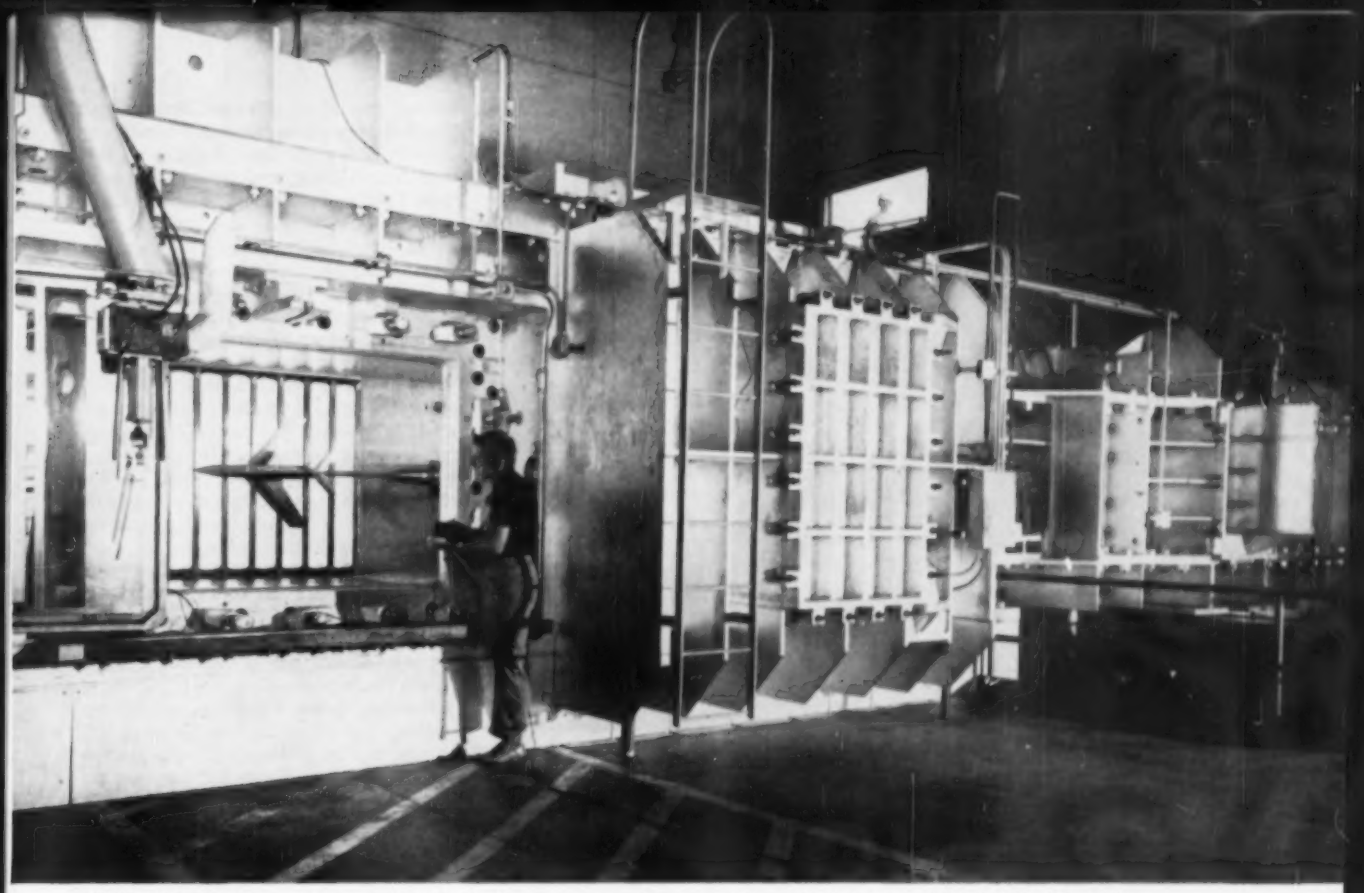
• **A high-speed leg** for the Unitary tunnel. Number two on NACA's construction priority list for its five installations, this high-speed leg would cost $750,000. Project includes construction of two fixed nozzles to cover the speed range from Mach 10 to Mach 12.

• **Hypersonic physics test area.** Cost of $1,987,900 would include chemical jets providing temperatures up to about 11,000F and hypersonic velocity guns to conduct research relating to problems of missile countermeasures and meteor impact problems. It will allow research on materials, structures and aerodynamics at all points along the range to extremely high temperatures and to Mach numbers of 20 or more. In addition to providing research information, it will increase knowledge of equipment and techniques for exploring these areas.

• **Hypersonic blowdown tunnel.** Cost is $796,000. For research at speeds and temperatures unattainable in wind tunnels, this facility will use helium as a test medium and operate in a Mach range from 10 to 25.

Modernization of existing research facilities in the coming fiscal year is to include modification of the 26-in. transonic tunnel at a cost of $346,400. An alternate 20-in. sq. test section will be installed to extend the Mach range from about 1.4 to 4.0 to permit investigations of the relatively unexplored problems of flutter in higher Mach numbers.

Langley also is asking for $3,067,200 for modernization of its data reduction center, and $858,000 for improving the air supply for the Internal Flow Laboratory. Increasing need for structures research at high temperatures has made marginal the existing central compressor, which supplies air to several



UNITARY PLAN supersonic tunnel at Langley has two test sections, ranges from Mach 1.5 to 5. This is 4 by 4 ft. section.

facilities. Improved air supply will permit installation of additional compressor capacity at the Flow Laboratory.

Langley's complex of research facilities, scattered in an East Area and a West Area separated by Langley Air Force Base, includes 30 major wind tunnels, laboratories, test areas and a dozen large shops for instrument construction, model building, woodworking, machining and sheetmetal work.

Facilities Recently Added

Some of the newer facilities are:

• **Langley Unitary Plan Supersonic** Wind Tunnel. Extensive calibration on this $15.5 million continuous flow tunnel was completed last year, and the tunnel has been in operation since last August. It has two sliding block, variable test sections, each 4 ft. wide, 4 ft. high and 7 ft. long. One covers a Mach range from 1.5 to 2.7, the other from 2.5 to 5.0.

Test pressures can be varied from a partial vacuum to 10 atmospheres. Maximum Reynolds number per foot of length is 14 million for the lower-speed section and 9 million for the higher-speed.

Originally this tunnel was intended to fill the need for developmental tests on missiles. Since the lower-speed section also is appropriate to piloted aircraft, NACA expects this type of study to become a significant part of the tunnel's workload.

Air is supplied by a 100,000 hp. electric drive and a four-stage compressor section. Flow can be shifted from one test section to the other without shutting down. Six large shops are compartmented to protect proprietary interests of the private companies whose models are used in research studies.

Primary model support is a strut spanning the tunnel horizontally. Models are mounted with the wings vertical, and attached at the aft end to a sting support housing 312 pressure tubes and 120 electrical leads used for obtaining data. Other data-recording equipment includes force balances, strain gages, and a 40-channel integrating manometer. A schlieren system utilizing two highly-accurate parabolic mirrors, 49 in. in diameter, provide for flow visualization.

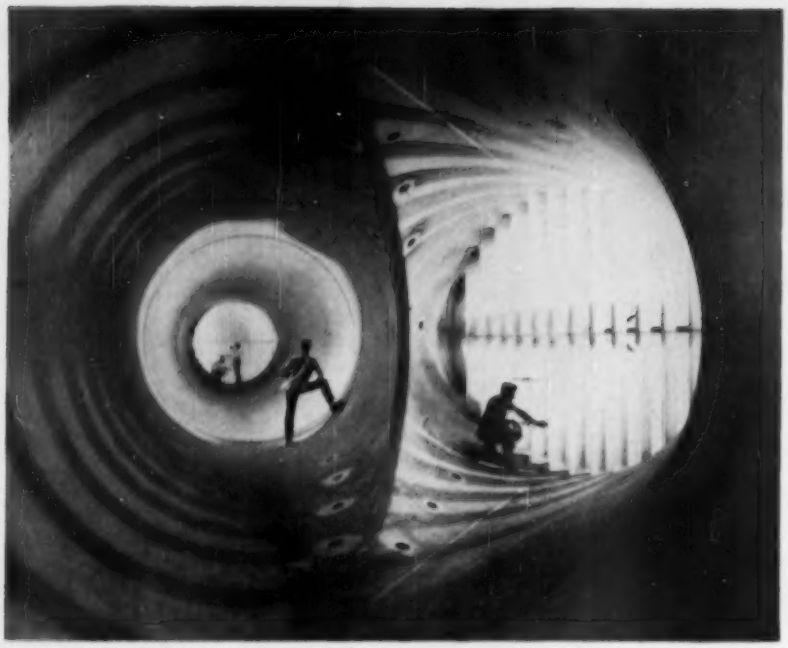
High on the priority list for study with this tunnel is the decrease in directional stability that occurs as speed increases—a major problem in supersonic fighter design.

Conventional lifting surfaces at high speeds lose effectiveness to the point that positive directional stability becomes unacceptably low. The variable speed tunnel can determine not only at what point stability of a particular design begins to decrease, but the point at which it becomes too critical to accept.

• **Supersonic blowdown tunnel.** Due to operate this year, this will answer the need for a larger supersonic heating jet than Langley has had. Test section will be 8½ by 6 ft. and Mach range will be 2 to 3. Air stored at 7,000 psi. will be preheated in a heat accumulator holding 600,000 lb. of stainless steel sheeting and fed by an oil-fired furnace. Duration of the jet will be 15 sec. Turntable in the test section will allow varying the angle of attack, which in turn will vary structural loads. Exhaust thrust of the heated air after it passes the test section will be 750,000 lb., the equivalent of almost two billion jet horsepower. Air will be exhausted over a swampy area where there is no habitation.

• **Full-scale ceramic heat exchanger.** Based on experiments with a pilot model, this will give researchers information at temperatures near the melting point of metals used in previous heat exchangers. The pilot model stores air above 4,000F and blasts a jet of air at that temperature over a tiny model at 3,500 mph. Diameter of the jet is only three-quarters of an inch.

NACA feared that the steep temperature and pressure gradients developed



SHADOW PATTERNS mark juncture of air passages to Unitary tunnel test sections.

independently in high speed air streams might upset test results. Rather than risk the waste of scarce funds on a major project, NACA built the scale model first. Fears about the effect of gradients in the stream failed to materialize.

The jet nozzle in the pilot model is water-cooled to keep it from melting or changing shape in a way that might affect speed, smoothness, flow direction.

• **Landing Loads Track.** This unique facility, used to study loads on landing gear in high-speed landings, is propelled by water. A 50-ton test carriage is catapulted by a hydraulic jet at speeds up to 150 mph., along a 2,200 ft. track. Water stored at 3,260 psi. air pressure is directed in a jet toward the rear of the carriage. A "bucket" on the rear of the carriage reverses the flow of the water, and the jet stream's change in momentum produces a thrust of 400,000 lbs.

Carriage is accelerated to 150 mph. in 400 ft. and 3½ sec. After catapult, the carriage coasts along the track for 1,200 ft., where the simulated landing is made by the test equipment. The carriage is stopped within the last 600 ft. by a grooved nose block which engages five cables stretched across the track and attached to 20 Navy Mark IV arresting gears, each capable of absorbing 4 million foot-pounds of energy.

Equipment being tested drops freely on the test rig until the desired vertical velocity is reached. An instant before the equipment contacts the concrete runway between the rails of the track, an engine applies a prescribed vertical force to simulate lift of the aircraft's wing.

Data on the landing gear as a shock absorber, the physical nature of skidding processes during wheel spin, elastic behavior of tires in yawed rolling, and other effects are measured by instruments.

Cost of a run is less than five dollars, compared to about $6,000 if rocket power had been used.

An outdoor water basin is built alongside the track to supplement the two indoor towing basins used by Langley's Hydrodynamics Research Division. An arm on the carriage tows a model along the basin in high-speed hydrodynamic studies.

Along with its other modernization, Langley soon will return to use the 19-ft. pressure tunnel, which is being converted to use Freon as a test medium.

Power Consumption Rises

Return of this tunnel to use and planned full-year operation of the Unitary tunnel will add to Langley's great power consumption. They account for $192,000 of the $384,600 increase in power costs expected in Fiscal '58.

Langley's consumption from the Virginia Electric and Power Co. totaled 112,956,400 kw. in Fiscal '57, and will run to 150,744,000 kw. next year. Cost of this vast amount of electrical power in Fiscal '57 was $1,520,400. It will run $1,905,000 in the upcoming year.

In addition to the power it obtains from outside, Langley supplies supplemental "topping power" from its own 10,000 kw. generating plant.

Remainder of the increase in power need for next year will result from utilization of the 16 ft. transonic tunnel and the 4 ft. supersonic pressure tunnel.

Fact that a number of facilities for exploring heating and structural problems have just come into being or are still in the planning stages, does not mean that Langley is just beginning to investigate these problems.

For several years Langley has used supersonic air jets and other devices to simulate heating effects on aircraft at higher speeds.

In addition to shock tubes and the ceramic heat exchanger mentioned above, tools and techniques for exploring these problems include:

• **Radiant heating devices** such as the electric carbon-rod radiator, which will heat to 4700F and produce the heating rates up to 1000 Btu. per sq.ft./sec. that a missile, being accelerated rapidly to Mach 5 at low altitude, would encounter. Advantage is a simple type of heating. Disadvantage is that the heating rate cannot be varied rapidly, as it would be in flight.

• **Heating-loading devices.** Variable heating, desirable in this type of research, can be produced by quartz-tube heat lamps, which can be arranged in banks to surround any size or shape of test material, and can be heated and cooled very rapidly. These lamps can be used, for example, in studying the difference in thermal expansion between an aircraft's skin and the skin stiffeners. They have been used at Langley both for this and to study unsymmetrical wing heating. A small wing structure heated to 800F on its undersurface and 200F on top, as it would be in the pull-up of a missile, droops downward as much as several inches at the wingtip. Cooling returns the wing to its normal shape. Quartz-tube heating also can be done while distributed loads are being applied, to test the combined effect on a structure.

• **A free-piston compressor,** made up of two 6-in. Navy gun barrels, which can compress air to temperatures of several thousand degrees.

• **Pre-flight jet facility** at Langley's Pilotless Aircraft Research Station on Wallops Island, Va. This facility includes a 12-in. circular ethylene jet producing temperatures of 3,000-3,500F, and a blowdown tunnel. The tunnel has a 27 by 27 in. nozzle which can range from Mach 1.4 to 2.25, giving true sea level density and temperature at all numbers and having a 5-8 sec. running time at Mach 2.25; a 12 by 12 in. nozzle with a 60 sec. run at Mach 1.4; and an 8-in. circular jet. This pre-flight facility is used for studying stagnation temperatures, heating, structures and ramjets.

• **Rocket jet,** using exhaust of a liquid-propellant rocket, which can subject models to a 5,000 mph. blast of air at 4,100F. Nozzle diameter is 2½ in.,

and models may be up to one inch in diameter. Exhaust products are oxygen, nitrogen and water vapor, the major constituents of air. One use is in materials testing. Titanium nose cones, raised to 3000F to simulate a speed of Mach 7 at altitude, bursts into flames and is destroyed because of titanium's increased affinity at high temperatures for nitrogen and oxygen.

Heating studies at Langley have shown that heat is an important factor in susceptibility to flutter. Flutter resistance of a control surface is sufficient if the surface is uniformly hot or cold, but sharp leading and trailing edges concentrate heat, leaving the center of the surface cold.

Resulting stresses cut torsional stiffness and set up self-excited flutter which can destroy the surface rapidly. If the surface survives, flutter will damp out as heat spreads to equilibrium.

Heating also is studied at Langley with gas-launched projectiles and full-scale aircraft, and at Wallops with rocket-launched models of aircraft and missiles.

New Model Techniques

Models are used extensively at Langley, both in and out of wind tunnels, to investigate aerodynamic and stability and control problems of vertical and short-takeoff and landing aircraft, spin characteristics of new military and research aircraft, and hydrodynamics of new designs, including ditching characteristics of most new models, especially commercial transports.

Two of the newest techniques for model use are:

• **Helicopter-dropped,** radio-controlled models to study incipient spin. High-speed spins in supersonic fighter and research aircraft have become so critical that emphasis is on ways to prevent spin from happening. Aside from investigating best recovery techniques, Langley's Spin-Tunnel Section is putting great effort on prevention methods such as wing or tail parachutes, counter-spin wing-tip rockets, etc.

• **Radio-controlled models** flown to high altitudes to achieve conditions which are difficult to simulate. Radio models, powered by hydrogen peroxide jets, will permit larger-scale models and study of the entire flight range in VTOLs and STOLs. Jet-augmented flap, aimed at increasing lift and cutting the runway length required for military and commercial jet aircraft, also will be investigated.

Langley's pioneering work on VTOL/STOL aircraft continues, with a high interest and participation from industry. In addition to the planned radio models, dynamic models are flown out of doors, in the full-scale wind tunnel, and mounted on crane booms, both from a rotating crane and on a truck, where roll, pitch and yaw may be simulated accurately.

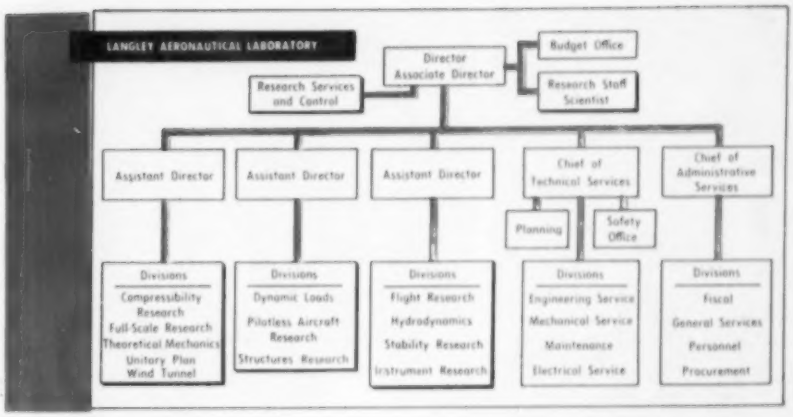
Research into piloting problems at Langley ranges from simulators to full-scale aircraft.

Emphasis here also is on high-speed, high-altitude flight. Disappearance of aerodynamic force in rare upper atmosphere, growing distance between top and bottom of the speed scale, and changing aerodynamics at high Mach numbers produce many problems.

NACA test pilots who have tried a small, finger-tip control stick mounted on the arm-rest prefer it to the larger, floor-mounted stick. It allows more time for attention to target and requires less for control of the plane. This also would reduce induced stick motion, which becomes increasingly dangerous at high speeds and altitudes, where pitch and yaw are relatively undamped.

Studies of aerodynamic and piloting problems at advanced speeds and altitudes have led to consideration of variable geometry wings and more nearly automatic control systems.

Instability problems are simulated on the ground by a cockpit mounted in a high-speed elevator in the center of a half-cylindrical, two-story screen. Simulation is limited to the vertical plane but the programmer can simulate stability characteristics of current aircraft, manned hypersonic rocket gliders, or ballistic vehicles.



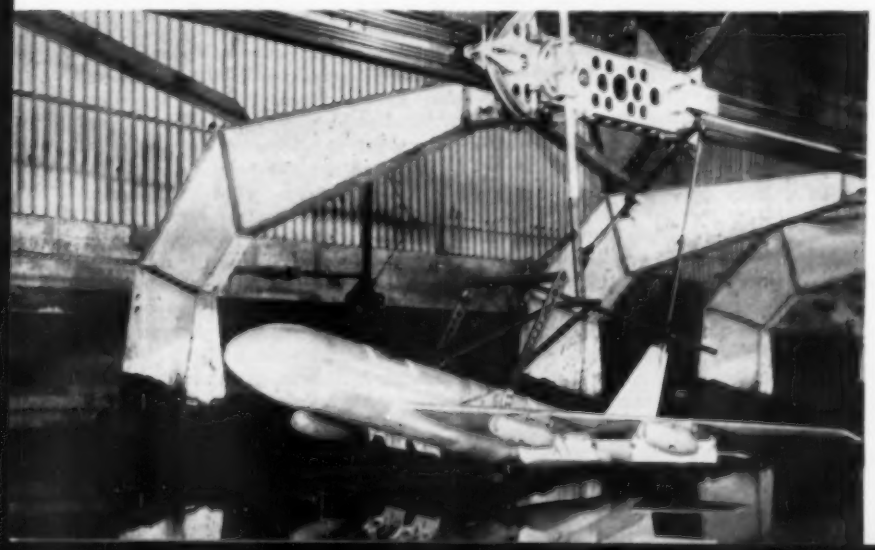
$28 Million Budget Asked

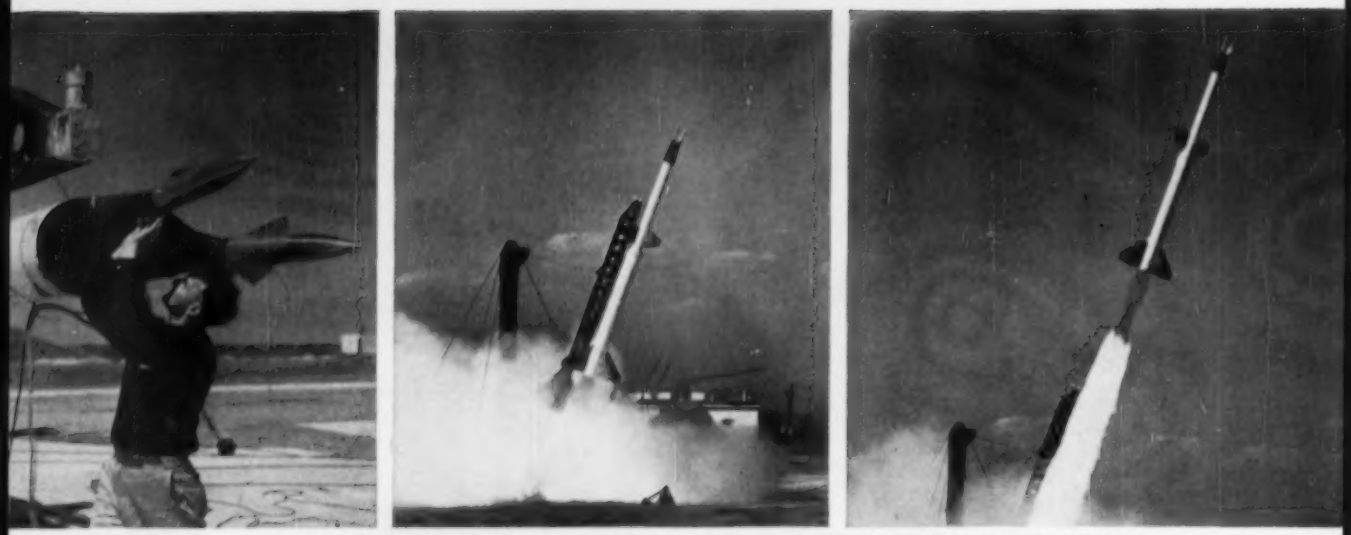
NACA has requested $28,671,000 for Langley's operating budget for the fiscal year beginning July 1. As at many research installations, biggest item is for personnel—$20,118,000.

Langley employs 3,331 and hopes to increase this to 3,650 in Fiscal '58. Of this total, 76 additional men would be needed to staff the new high-temperature structures research laboratory. Another 129 would be needed to accelerate the research effort. Approximately 1,000 of the employes are aeronautical research scientists and engineers. The rest are mechanics, technicians and other supporting personnel. Director since 1926 has been Dr. H. J. E. Reid.

High costs of facilities, higher salaries, and the loss of personnel to industry because salaries still are not high enough is affecting Langley, just as it is most research efforts. ■

DYNAMIC model of Boeing transport readied for ditching test in towing tank.





TWO-HEADED research model is used to study heat transfer problems in man-carrying aircraft traveling at speeds of Mach 5.

Wallops Gathers Hypersonic Flight Data

Wallops Island, Va.—Actual flight data to be applied to intercontinental ballistic missiles and manned hypersonic aircraft is being gathered daily at the Pilotless Aircraft Research Station here.

This remote outpost of National Advisory Committee for Aeronautics' Langley Aeronautical Laboratory was established 12 years ago in an attempt to keep U. S. aviation ahead in transonic and supersonic flight.

Five-Stage Rockets Fired

Now it is in the forefront of hypersonic research. Five-stage rocket vehicles, fired into the Atlantic Ocean in NACA-developed "over-the-top" launching techniques, telemeter back detailed aerodynamic and structural data at velocities up to and above Mach 12.

Results of Wallops' investigations have been incorporated into almost every major military aircraft and missile since the station was created. The Lockheed X-17, major vehicle for studying reentry problems of ballistic missiles, was based on devices and techniques established here.

RESEARCH models of aircraft are fired over Atlantic in aerodynamic tests.

Wallops is the research station for the Pilotless Aircraft Research Division at Langley, 70 miles away. For administrative purposes it is a part of PARD, but it maintains a separate budget so Congress will have a detailed account of what is spent on rocket launchings.

It is primarily a launching site, with a modest handful of shops, rocket assembly, test and storage areas; control and instrumentation sites, an administration building, and a pre-flight jet facility (discussed in the Langley article in this section).

Firings now run about 200 per year, in contrast to the 400 fired in peak years before models, instrumentation and launching vehicles became so costly and complex. For reasons of cost, simplicity and availability, Wallops uses standard solid rockets almost exclusively. They range from small motors to Honest Johns.

Average of successful firings at Wallops runs about 80%, in spite of the fact that almost every vehicle launched is a prototype.

Total firings since 1945 runs about 3,000. More than 1,000 of these were simple shapes with no instrumentation. Drag was measured and calculated with the help of radiosonde, the modified World War II SCR-584 tracking radar that is Wallops' workhorse, and a Doppler velocimeter.

Emphasis in current firings is on problems common to intercontinental ballistic missiles and the designs for hypersonic bombers that may follow them—materials, structures, designs and controls that will produce stable flight above Mach 5.

Missiles are the more immediate problem. But NACA says that winged boost glide aircraft appear to be one of the most promising design possibilities for future man-carrying vehicles.

They would gain part of their lift from centrifugal force and travel at Mach numbers up to 18 and altitudes above 300,000 ft. NACA says potential of this type of aircraft is practically unlimited.

Hypersonic Glider Design

Design characteristics of hypersonic gliders, based on what has been learned at Wallops and elsewhere, might be:

- **High fineness ratio nose cone.** Blunted missile nose cone is necessary for rapid, almost vertical reentry into dense lower atmosphere, but gliders will have to achieve more gradual reentry to keep from burning up pilot and plane.
- **Variable geometry lifting surfaces.** Very thin, low aspect ratio wings desirable for high-speed flight will not produce the high lift necessary for coasting flight at lower altitudes, or for landing.
- **Reaction type controls.** Effects of conventional control surfaces at extremes of speed and altitude would be intolerably low because of thinness of the air and very high inertia of the aircraft. Pulse-jets at wingtips and tail seem most likely.

Joseph A. Shortal, chief of the parent Pilotless Aircraft Research Division at

Spiraling Cost of Research

Facility	1946 Cost	1956 Cost
Wind Tunnel		
Construction	$960,000	$27,000,000
Power cost	3,400	1,650,000
Payroll	126,000	845,000
Instrumentation	14,000	920,000
Model construction	4,000	85,000
Power consumed in hp.	2,000	200,000
Personnel	40	147
Altitude Chamber		
Construction	$76,000	$18,500,000
Payroll	26,000	426,000
Instrumentation	2,000	143,000
Power cost/hr.	10	900
Personnel	8	74
Rocket Research		
Construction	$46,500	$400,000
Payroll	55,000	260,000
Model & setup cost	10,000	150,000
Instrumentation	3,000	60,000
Fuel cost/lb.	.50	15
Personnel	13	40

Source—Fiscal 1958 budget hearings, National Advisory Committee for Aeronautics

FIVE-STAGE vehicle fired "over-the-top" probably reached speed of Mach 12.

Langley, said his division has been working with heating speeds nearing the transonic range for at least four years. Mach 10 research already is almost three years old at Wallops.

Primary Research Areas

Primary areas of research at Wallops now include:

• **Aerodynamic heating.** Earliest work was done chiefly to confirm heat transfer theories originally worked out with boiler pipes. First firing was in 1946. Original test vehicle, the magnesium-bodied RM-10, reached Mach 4 and 100,000 ft. five years ago. Magnesium was good to this velocity before researchers had to switch to Inconel. Models now are of two general shapes—high fineness ratio nose cones applicable to long-range aircraft such as the rocket glider, and blunt noses which will have to withstand higher heating, but for a shorter time. Heating research is vital to all Wallops' work, because materials must be found which will not burn up before studies can be conducted on drag, interference, aeroelasticity stability and control.

• **Automatic control.** General research in this area has been going on since Wallops was established, but emphasis now is in stabilization and control of missiles.

• **Flutter.** Once the sole source of data on flutter, free-flight launchings may again come into prominence as heating problems aggravate flutter. Temperature alone can cause changes in wing stiffness, resulting in violent flutter of control surfaces.

• **Dynamic stability.** Percentage of effort in this area remains fairly constant, with about a dozen launchings a year. Models are complex and data reduction is complex. Since models are entirely free and give true effects, correlation between test data and actual flight tests is high. Test models have included McDonnell F-101, Lockheed F-104, and Hughes Falcon missile. Pulse rockets, mounted at right angles to the line of flight, are used to disturb the model. Lift, drag and stability data are determined from the resulting oscillations.

• **Control effectiveness.** Models can be flown with fixed control deflection and rate of spin measured by means of polarized radio signal, transmitted from a spinsonde unit in the nose. Effectiveness of both aerodynamic and jet vane controls have been studied.

• **Ramjets.** Done intermittently in conjunction with NACA's Lewis Flight Propulsion Laboratory at Cleveland, Ohio. Work on inlet and combustion problems at Lewis and Wallops brought the ramjet engine for the Navaho missile from far below design performance up to design performance.

• **Jet effects and inlets.** This includes study of the flow from a jet engine and its effects on trim and lift of tail surfaces; and research into pressure recovery, drag loss, etc., of flow into engine inlets. Like almost all of Wallops' work, it is supplemented by and coordinated with wind tunnel and actual flight data.

Wallops' requested budget for next year is $1,146,640. Staff will be 89—half a dozen more than the present complement.

Another $2,560,000 has been asked for modernization of Wallops' outdated equipment, which now is limiting range of launchings. This would provide for an increased-range Doppler, telemetry equipment, and two new tracking radars.

Work at Wallops is directed from Langley by Robert Krieger, and John C. Palmer heads the research section on the island proper. ■

BELL X-1B, X-1E are exploring high-speed heating areas in attempt to fill gap left by crash of faster X-2 research aircraft.

Edwards Pioneers High-Speed Research

Edwards, Calif.—Where other agencies explore and exploit maximum capabilities of an aircraft, National Advisory Committee for Aeronautics' High-Speed Flight Station attempts to gain every data point possible within a vehicle's complete operational envelope.

Directed toward accomplishing this mission are:

• **A stable of research aircraft,** both modified and operational military planes, ranging from a two-place World War II North American F-51 Mustang to the record setting Douglas D-558-II Skyrocket and including the Bell X-1B and X-1E rocket planes, Boeing B-29 launching planes for the X aircraft; a Boeing B-47, a Lockheed F-104A, a Convair YF-102 and the Bell X-5. Other operational types come and go as NACA is asked to help solve specific problems. NACA also gets aircraft on loan when it develops an investigation program which the particular plane is well equipped to conduct. The station, under the direction of aeronautical research scientist Walter Williams, conducts some 200 to 250 research flights per year.

• **A complement of 294 people,** broken down into 50 research engineers, 14 instrument engineers, 5 operations engineers, 4 mathematicians, 4 test pilots, 18 laboratory and other technicians, 66 aircraft mechanics, 40 instrument mechanics, 23 building and equipment maintenance personnel, 59 administrative personnel, including technical librarians; technical report typists and secretarial staff.

• **Equipment enabling the station** to deal in the "flight package." This includes supporting and mounting the flight, taking data, reducing and analyzing it, and correlating it with wind tunnel, calculated and extrapolated information to complete the detailed picture of the area being investigated.

• **A main buildings complex** worth $4,006,523, warehouses worth $62,190, and equipment (not including airplanes) which brings the total station value to $12,429,629. The station, situated on several acres at the edge of Rogers Dry Lake and adjacent to the main Edwards AFB flight line, is a tenant of Air Force Flight Test Center.

In performing its mission, NACA has developed a step-by-step flight test programming philosophy, in contrast to a contractor's goals of specified demonstrations, and the military's tests for ultimate performance. Tests at the station are profiled to enter unknown regions far enough to gather new facts, but to stay close enough to known areas that hazards to pilot and plane are minimized.

The station takes information already gathered in flight tests, adds wind tunnel, calculated and extrapolated data plus results of simulation performed on an analog computer, and plans a flight—using this combination as indicative of what may happen, but not as a guarantee.

When the station embarks on a program, it gets whatever support it requests from wind tunnels and other NACA facilities. Conversely, test results are quickly disseminated to NACA groups investigating the same areas.

In addition to the standard, unclassified publications which record these investigations, information in new and classified areas is distributed to contractors where it is applicable, to assist in avoiding design pitfalls in upcoming airplanes and to contribute to performance stretchout or needed fixes on current airplanes.

X-15 Advanced Data

Illustrative of this, NACA is circulating advance information on the X-15 design throughout industry. Although circulation is on a highly classified basis, it is expected to bring the widest possible experience and array of talent to bear on problems encountered in this research vehicle. NACA's position on

the X-15 is that of a design information coordinator, an assisting agency in background and research work and, ultimately, a customer.

While NACA deals much of the time with research aircraft, it may be loaned an operational type by the services where the need arises. This may be on the basis of a proposed NACA investigation far afield of contractor and USAF work in the airplane's development, or to aid fixes on current problems.

Examples of the station's work on two operational models are the Convair F-102A, where XF-92A research eliminated many possible problem areas in the new supersonic delta configuration; and the North American F-100, where NACA's independent investigations in stability augmentation helped overcome inertial coupling characteristics by changing gain and authority of the pitch axis damper.

Carrying out the research programs at the High-Speed Flight Station are branches on Stability and Control, Dynamic Analysis, Aero Structures and Performance, plus Sections on Data Reduction, Vibration and Flutter.

Own Instrumentation Used

NACA instrumentation is keyed to each particular requirement. Wherever possible, standard off-the-shelf components are used, but primarily the station has developed its own hardware to match its philosophy.

Instrumentation is used to describe and record aircraft movements about all axes, angular and linear velocities and accelerations, control positions and forces, aerodynamic pressures and distributions.

When the station gets an aircraft for its investigations, instrumentation down-time is minimized by installation of NACA's own packages. In military planes, removal of gun installations frequently provides the needed shelf space and access to power supply. Participating in early design of research vehicles gives NACA a better break in incorporating provisions for their specialized instrumentation. Biggest headache is devising new packages for the very high density research vehicles and military aircraft of today.

X-1E AIRCRAFT, slung in belly of B-50, is prepared for research flight.

Flight data is gathered by light trace on standard 120mm. and 6-in. film strip, purchased in bulk and magazine loaded. Each size provides a number of information channels and a standard timing channel triggered by a central clock in the airplane, which gives the same light trace on all instrument records for the purpose of matching strips later.

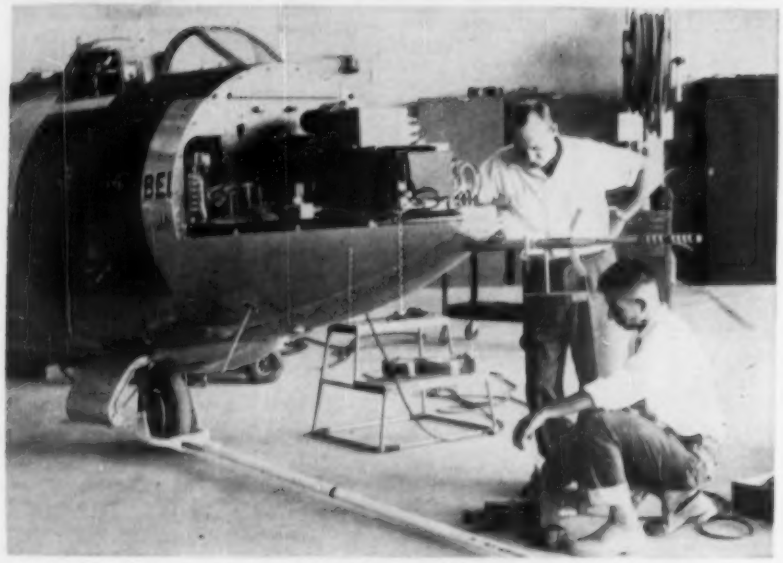
While film is the primary airborne record, NACA does not believe tape recording is the answer to its requirements as yet. Oscillograph paper trace also is used, mainly for strain gage recording.

Telemetry is used, but on the basis of giving the pilot of a cramped research vehicle the services of a flight engineer. Tape recordings are made during each flight. The telemeter panel is monitored closely during research flights so that warnings can be radioed immediately if readings indicate danger in an area invisible to pilot and chase pilots.

When a research flight has been completed, film records are developed quickly by the photo section and sent to data reduction and analysis offices. With the film system used by NACA, engineers immediately have available a look by naked eye or a more detailed inspection on a telereader.

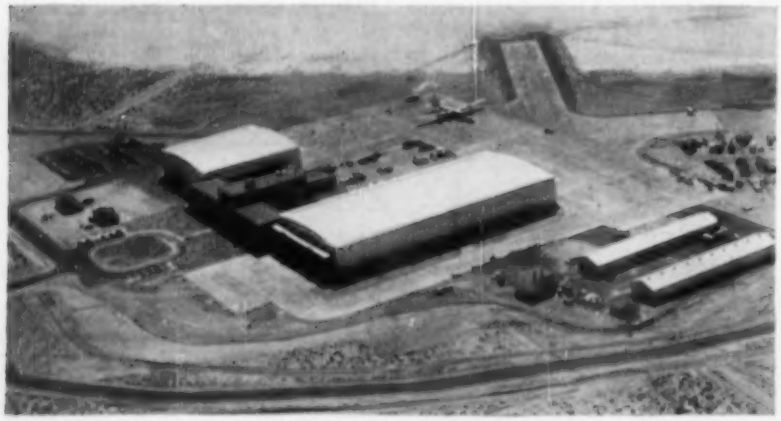
Currently, films are run through the Telereader and data points are read off and plotted by hand. As data points are typed onto log sheets, cards for an IBM computer are punched simultaneously. Soon to be installed is a machine which will plot data points, type the log sheets and punch cards

EDWARDS work on F-100A inertial coupling problem led to larger vertical stabilizer, left, changes in pitch damper.



BELL X-1B *is instrumented for heat studies in calibration and modification hangar.*

'IRON CROSS' controls are three air jets. X-15 aircraft will use jet tip controls.



CALIBRATION hangar, left, and storage and maintenance hangar flank offices.

simultaneously. The station also has equipment for transferring the oscillograph records onto IBM punch cards.

In support of its flight test work the station has the use, where practical, of USAF's Air Force Flight Test Center facilities. AFFTC supplies the station's fuel and usually provides chase pilots and airplanes. Where absolutely necessary, the station backstops with its own pilots.

The station schedules with AFFTC on use of facilities which are part of the AFFTC complex, such as the high speed flight path from Edwards over 400 mi into Nevada. Instrumentation for this path now is being completed.

The station has its own SCR-584 radar, as modified by Langley for use at the Pilotless Aircraft Station on Wallops Island, for speed calibration runs. For a time, AFFTC used this NACA facility, since it was the only one at Edwards.

Expenditures budgeted for the station are at the rate of some $2.5 million per year for salaries, acquisition of new equipment and repair and replacement of worn equipment, utilities, locally purchased supplies, and travel.

Facilities at the High-Speed Flight Station include:

- **Hangar, used primarily** for calibration and modification of aircraft. It also contains an "erector set" for applying loads as desired to all sections of the airplane. Also housed here is the "Iron Cross," test rig for determining pilot reactions to various presentations of unusual flight attitudes and conditions such as vertical takeoff.

  The cross also uses compressed air jets on three arms (pilot cockpit is on the fourth) for flight controls, instead of conventional surfaces. This is useful in preliminary investigations of research vehicles such as the X-15, which probably will have this type of control for very high altitudes where conventional surfaces are all but useless.
- **Instrument shops** capable of complete repair, overhaul, calibration and test, and a machine shop where new instruments can be built from scratch for a particular need. The station gets instrumentation support from Langley Laboratory in the design of new flight packages or specialized installations.
- **Second hangar** for airplane maintenance and storage of aircraft involved in the various research projects. All rocket engine work is done here, as are minor repairs on turbojet and piston engines. Major engine work is handled by the Powerplant Branch of AFFTC.
- **Photography laboratory** for handling the instrumentation film records on a high-output basis, as well as standard photographic work.
- **Main building,** housing engineering offices, data center and administration offices. ■

USAF-MCDONNELL F-101B Voodoo armed with three Hughes air-to-air Falcon guided missiles.

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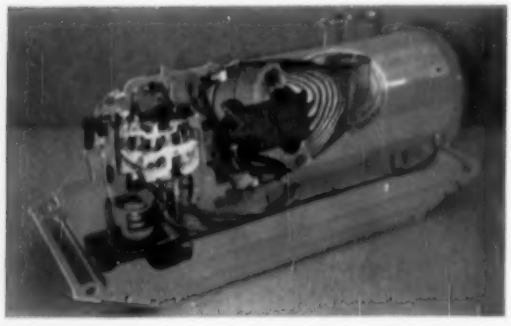

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✔ Herman Nelson engineering and research unquestionably spearhead the portable heat industry.

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Circle Number 186 on Reader-Service Card

ARDC Insuring Airpower Supremacy

Baltimore—Air Research and Development Command, with a complement of less than 40,000 men, manages the nation's largest integrated research and development program for the U. S. Air Force.

In addition to coordinating the efforts of some 3,000 industrial firms, research institutes and universities, ARDC conducts a limited amount of research and technical development itself at 11 centers from Massachusetts to Southern California.

As its challenge, ARDC has the mission of insuring the supremacy of USAF's airpower—no small task at a time when the Soviet Union has demonstrated a startling ability to marshal technological manpower and know-how and apply them to aerial and nuclear weapons.

At its disposal ARDC has what Lt. Gen. Thomas S. Power, its commander, calls "a management tool unique in the history of military warfare"—a team composed of government's funding and direction, industry's development, engineering and production ability, and the knowledge of science—all of them indispensable in an age where technological advance is measured as a geometric progression.

ARDC was created in 1951 when Air Force recognized that it must have a separate research and development command if it was to keep pace with the growing complexity of weapon systems.

$2.5 Billion in Facilities

ARDC now has a $2.5 billion complex of research, development and testing facilities where Air Force laboratories and contractors may prove out the ideas that will insure technical superiority for airborne and supporting weapons.

More than $600 million in research and development funds are allocated directly to ARDC. Additional funds allocated for procurement, production, construction, etc., in support of ARDC's effort run to more than $2 billion.

In line with Gen. Power's philosophy that ARDC must be only "a manager and monitor of the Air Force research and development program," more than 80% of USAF's work in this field is done outside the command, on contract.

Operational requirements with which ARDC deals are determined at the headquarters level of USAF. ARDC then forms development directives to support these requirements, and passes them down to its command centers.

From the centers the work is contracted to university laboratories and commercial firms with a proved capability in the particular field, and eventually new systems are developed and returned to ARDC for testing.

Three-Part Task

ARDC sees its task as broken into three primary aims:

- **Improve the quality** of future USAF weapons, by undertaking research programs that are daring and imaginative enough to be aimed at major technological breakthroughs.
- **Increase reliability of weapons** ready to go into USAF's combat inventory. This is the job of translating new equipment into standard production-type products of a sufficiently high degree of performance reliability to be trusted in routine operations—after their feasibility has been proved in the research and development cycle.
- **Reduce the development cycle** for new USAF weapon systems.

The flexibility that ARDC has maintained since its organization at Wright Patterson AFB, Ohio, six years ago is demonstrated constantly.

Less than two years ago, ARDC added a third Deputy Commander, in charge of Weapon Systems. This was a direct result of the surprising technological capability shown by the Soviet Union in its May, 1955, airpower demonstrations, and was an attempt to look for the "big jumps" in technology that Gen. Power says is one of ARDC's primary aims.

Within the past two years, the command has revolutionized its use of planning and management skills in an attempt to make better use of industry's capabilities and its own, and to combat the hampering effects of arbitrarily static budget levels.

To achieve the three main goals of improved quality, increased reliability and shorter development time, ARDC has developed basic new policies in recent months. They include:

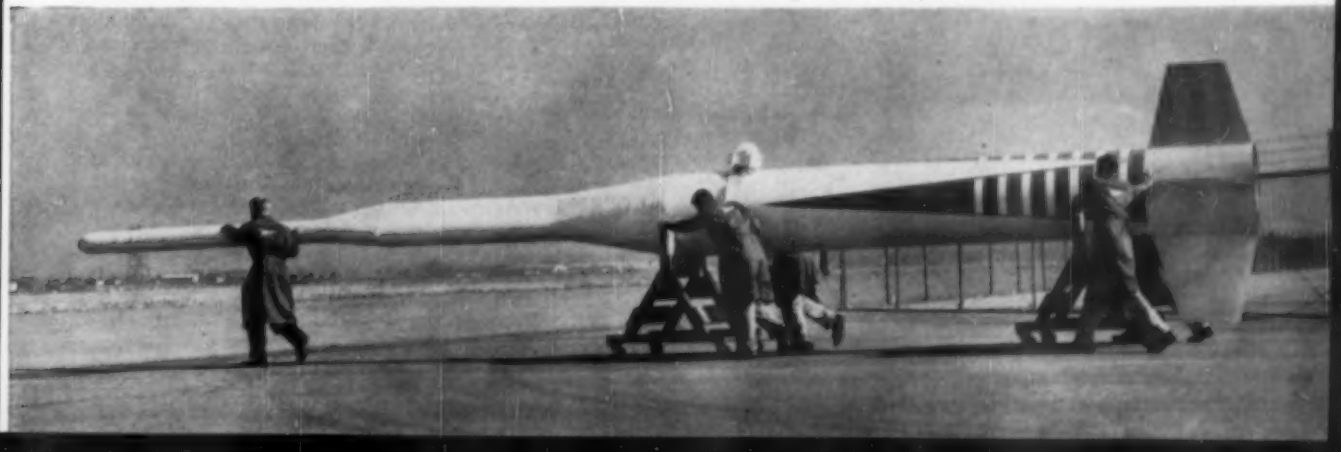
- **Closer partnership with industry** and science. Policy changes here have been aimed at bringing properly qualified industrial and scientific organizations into Air Force technical planning at the earliest possible phase, and at keeping a steady flow of pertinent information on technical problems and progress going to universities, private research groups and industrial organizations.
- **Heavier emphasis** on exploratory research. Before ARDC was created and during its early history, an overwhelming portion of its effort was devoted to development problems that continually arose on current hardware.
- **Long range planning.** Proper direction of an increasingly difficult research and development program obviously requires planning aimed 10 to 20 years ahead.

Headquarters Organization

ARDC headquarters is organized under three functional deputy commanders:

- **Research and Development** under Brig. Gen. Marvin C. Demler.
- **Weapon Systems** under Maj. Gen. Albert Boyd. In addition to Assistants for Aircraft Systems, Guided Missile Systems and Electronic Supporting Systems, Gen. Boyd has Directorates for Nuclear Systems, Systems Management and Systems Plans.
- **Resources** under Brig. Gen. Kurt M. Landon. ■

LOCKHEED X-17 re-entry research vehicle for ballistic missiles is rolled from hangar at Van Nuys, Calif.



CHUTE slows landing of jet-powered X-10, research vehicle for ramjet powered North American Navaho strategic missile.

WADC Aids All Air Weapon Systems

Wright-Patterson AFB, Ohio—Wright Air Development Center, first home and largest base of the Air Research and Development Command today is a principal supplier of technological know-how for:

• **USAF's Weapon System Project Offices,** the gateway to Air Force management of a project. There is an office for every system, under ARDC's executive responsibility during the development stage and under Air Materiel Command as soon as technical and operational excellence seem to be within reach.

• **Air Materiel Command,** which depends on WADC for technical information needed for procurement of weapon systems.

• **Using commands,** which need technical data to maintain and modify weapon systems already in operation.

WADC sponsors and monitors applied research and exploratory development across the board in aeronautical sciences, then monitors evaluation and production.

WADC's dozen laboratories are split between the Directorate of Research and the Directorate of Development.

Two Responsibility Areas

In these directorates and laboratories, staff responsibilities divide into two areas:

• **Technical development,** focusing primarily on techniques in aeronautics, guidance, etc., to explore and advance the state of the art and to produce material for the System Requirements studies carried out by industry under ARDC sponsorship.

• **Operational development,** dealing with specific hardware and keeping the weapon system concept in mind, employing existing knowledge to help finalize specific sub-systems.

For production contractors, the operational area is the important one, where the Weapons System Project Office or Electronic Supporting Systems Project Office will go to get cooperation from WADC's laboratories. Technical responsibility for each subsystem lies with Laboratory Operational Development staffs, who speed and improve scheduling of contracts, detect and correct defects when they appear, and dovetail sub-systems into weapon systems.

WADC, the command's largest installation, has 200 buildings spread over 4.5 million sq. ft. and employs some 8,000 military and civilians.

Laboratories in the Development Directorate are Aircraft, Aerial Reconnaissance, Communication and Navigation, Equipment, Flight Control, Propellers, Powerplants, and Weapons Guidance.

Research Directorate Laboratories are Aero Medical, Aeronautical Research, Electronic Components and Materials.

Four other directorates cover Flight and All-Weather Test, Procurement, Engineering Standards, and Support.

Development directorates and their tasks are:

• **Aircraft Laboratory** handles basic problems of airframe structures and aerodynamic shapes in its six wind tunnels, ranging from 6 in. to 20 ft. in diameter, and a structures test building.

It also deals with equipment that might affect aerodynamic capability, such as external pontoons for helicopters; determines spin characteristics and stability of parachutes and bombs in the spin tunnel; and considers escape problems in supersonic aircraft.

• **Powerplant Laboratory** studies turboprop, turbojet, ramjet, pulsejet, liquid and solid propellant rocket engines, reciprocating engines and nuclear propulsion. Turbojet test stands can take power units up to 40,000 lb. sea level thrust.

• **Propeller Laboratory** whirl stands for both subsonic and supersonic propellers are powered by motors up to 30,000 hp. and capable of speeds up to 12,000 rpm. Helicopter rotor whirl stands can handle rotors up to 95 ft. in diameter at 140 to 600 rpm.

• **Aeronautical Research Laboratory** cuts across traditional lines of science to seek solutions to problems in a number of areas, including heating, structures, flutter, bombing computers, fire control and equations of motion.

• **Materials Laboratory's** task is development of new materials and creation of substitutes for critical items. It also establishes quality standards for all USAF materials.

• **Electronic Components Laboratory** does research and development on airborne electronic equipment, ranging from transistors to radomes.

• **Communications and Navigation Laboratory** handles new and improved communications, identification and navigation equipment and systems for both aircraft and missiles.

• **Flight Control Laboratory** develops improved flight instruments and manual and automatic flight controls. Goals are to make both manual and automatic flying easier and more accurate, and to facilitate shiftover from one to the other.

• **Aerial Reconnaissance Laboratory** deals with photographic, radar and infrared reconnaissance, including high-altitude cameras, cameras for use at low altitudes but in very high speed aircraft, stereoscopic photography, radar recording cameras, spark flash photography, night photography and photo installations in rockets and missiles.

• **Weapons Guidance Laboratory** covers problems of fire control, self-contained navigation systems, bombing and gunnery devices and weapons guidance. It is one of WADC's largest.

• **Aero Medical Laboratory's** task is to improve aircraft equipment so that man, who is obsolete in the world of high speed flight, can survive. It determines tolerance to modern flight forces, anticipates his future demands, and extends his capabilities. Altitude test chamber has taken a man to simulated altitudes over 190,000 ft.

• **Equipment Laboratory** handles a great variety of items from tiny filters to huge hangars. Depot equipment, electrical accessories, aircraft and missile servicing, auxiliary power vehicles, air conditioning, flight simulators, etc., fall within its province.

Patrick Tests Air Force, Army Missiles

Patrick AFB, Fla.—Long-range ballistic missile programs plus the increasing number of missiles that have outgrown the limitations of other service ranges, have sparked the rapid growth of the Air Force Missile Test Center.

The largest missile range in existence now extends more than 5,000 miles across the South Atlantic from the launching sites at Cape Canaveral to Ascension Island, Station 12, the southernmost in a chain of islands serving as down-range tracking stations.

With expansion of facilities, firing schedules have been increased and tightened to maintain Patrick's high utilization rate. Complaints of range saturation are not novel.

Present missile programs include those of Convair's Atlas, Douglas' Thor, Martin Matador, Chrysler Jupiter A, Northrop Snark, North American Navaho, Boeing Bomarc and Lockheed X-17. Present work load is about 250 tests per month, of which only a very small percentage are live rounds.

Operating costs remain at about $4 million a month. USAF and contractor personnel working with missiles or missile sub-systems are still on the increase. Total runs close to 10,000.

Scope of Range

Between the Cape and the island of St. Lucia, a distance of 1,500 miles, the range was built for aerodynamic missiles. Equipment was developed to watch missiles in level flight within the atmosphere at altitudes not exceeding about 20 mi. and slant range under 100 mi.

The Great Circle route between Cape Canaveral and Ascension, however, is off the island chain by a considerable distance. In some cases, one missile will never be closer than 100 miles from a tracking station.

The last few hundred miles before Ascension is used for measuring re-entry of ICBMs when the missiles plunge downward through the atmosphere to the impact point. During this critical portion of the flight precision tracking radars and command destruction must be available.

To meet expanding requirements of the IRBM and ICBM:

- **Monopulse radars** that can spot missiles at distances of several hundred miles have been developed.
- **Advanced optical** systems based on astronomical telescopes slaved to radars will yield visual data on missile attitude, stage separation and re-entry tumbling at distances in excess of 100 mi.

Convair's Azusa C-W system and the COTAR (Correlation Tracking and Ranging) system are being developed for ballistic missile tests. Former is under consideration as an input to impact point predictor; latter will be of primary use at remote sights for tracking the re-entry phase.

Impact points of long-range missiles can be located by listening techniques, comparable to underwater sound systems used in anti-submarine warfare.

Range errors as high as 10 miles over the complete trajectory of an ICBM could result from variations in the local acceleration of gravity. Gravity surveys are being made from Ascension Island back up to the Cape.

Range Safety System

Range safety system covers two time periods during a missile-firing: Zero to three seconds, during which the missile is lifting vertically and any variation from course means instant cutoff and a crash back on the pad; three seconds to burnout, during which any cutoff must be predicated on the impact point of the aborted missile.

Current system, Elsie (SLSE: Electronic sky screen equipment), uses a phase comparator on two pairs of radar sets at right angles, one pair watching the azimuth and the other the programming turn downrange.

Heart of the system for the second time period is an impact predictor consisting of three units: a C-W radar for tracking, a computer and a display device, which comprises both plotting boards and cathode ray tubes. It shows the range safety officer where the missile is and where it would fall if the power were to be cut at that particular instant.

Pan American, RCA Roles

Pan American World Airways and Radio Corp. of America have jointly operated the range during the past four years. Pan American is charged with administration, support, maintenance and housekeeping of the range. RCA does the technical work of data gathering, reduction, photo processing, report writing. Both report to the center commander, Maj. Gen. Donald H. Yates, through his Deputy Commander for Range.

RCA engineers begin work shortly after a contractor's test proposal arrives at the center, collaborating with Air Force missile project officers and engineers on instrumentation requirements, budgets, test planning, etc. RCA monitors tests. End product of their activities on the range is a final flight test data report.

Average time to produce a final data report now runs between 10 and 12 days.

RCA keeps several teams of maintenance inspectors roving the range, checking on station techniques for repair and overhaul.

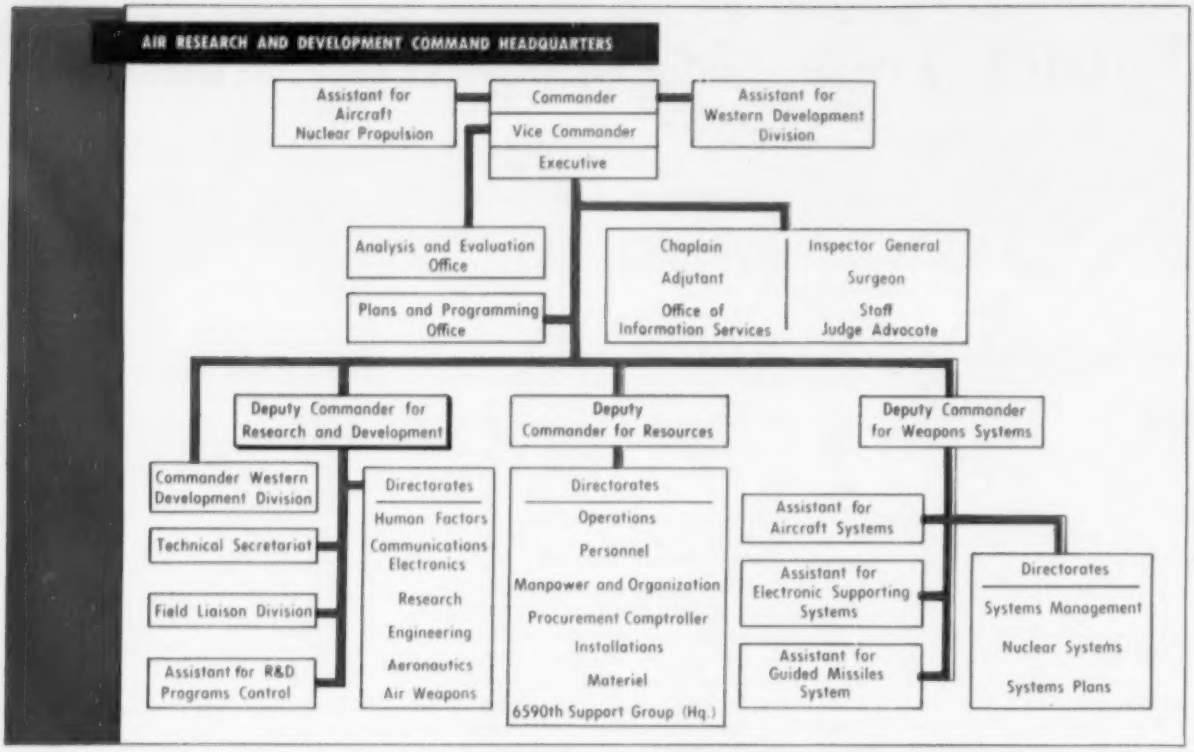
A contractor with a missile test program in mind utilizes the Test Requirements Handbook, which serves as a guide to center capabilities and as an outline for his test series. In its pages are complete descriptions of the range, instrumentation, operations, data gathering and reduction, and everything else he needs to know to plan adequately. It also contains blank forms which he uses to explain and justify his test plan.

The handbook is reviewed, and the formal answer to the contractor's proposal is the Test Support Plan, a folder of detailed test operations. With formalities and scheduling completed, contractor tests begin.

New Island Site

USAF now is establishing tracking and testing technical facilities on the island of Fernando de Noronha, about 250 miles off the extreme East Coast of Brazil. When completed this site will provide another tracking facility for the present missile test range, which extends south from Florida to Ascension Island. ■

X-17 RESEARCH vehicle is readied for night firing to test re-entry problem.



Kirtland Engineers Nuclear Delivery

Albuquerque, N. M.—Primary mission of the Air Force Special Weapons Center at Kirtland AFB is to mate nuclear and thermonuclear weapons with USAF's delivery systems.

But the center's task ranges far beyond the mechanics of making a weapon fit an aircraft and into a wide variety of research, development and engineering problems, affecting not only the hardware involved but the men who control these weapon systems.

Through the intricately entwined relationships of AFSWC, Atomic Energy Commission, Defense Department's Military Liaison Committee and the Armed Forces Special Weapons Project, every first line fighter, bomber and offensive missile in USAF's inventory has a nuclear delivery capability.

Vast technical progress of nuclear weapons has shaped the Special Weapons Center into a versatile organization with three units devoted to its primary missions:

• **Research Directorate,** concerned with analysis of future atomic and thermonuclear weapon designs and effects and employment of these weapons. It also is USAF's main liaison agency for future atomic weapons progress.

• **Development Directorate,** concerned chiefly with the center's "bread and butter" mission of marrying weapons to aerial delivery systems.

• **4925th Test Group,** providing test support for research and development at Kirtland and for Sandia Corp., and air support for AEC's weapons testing.

Research Directorate's most important product is paper-studies-analyses and ideas on future nuclear weapon system designs and methods of using them; personnel hazards in handling them and how to counteract these in offensive and defensive warfare; human engineering on the specialized equipment demanded by nuclear war.

Directorate's divisions and their main duties are:

• **Analysis** determining future needs, including types, weights, sizes, costs, yields, etc., of nuclear weapons and how they fit into USAF's combat mission for effective delivery against USAF targets. One major contribution is the low altitude bombing technique, originally developed for fighter-bombers and now applied also to strategic bombers.

• **Effects.** Goals are data on detonation effects, yields, radiation and fallout results, best detonation altitudes.

• **Bio-physics.** Task is to measure, evaluate and devise counter-measures for personnel hazards of nuclear warfare. Problems are permissible radiation dose to personnel in combat, safe techniques for decontaminating "hot" aircraft, development of airborne radiation measuring instruments, reduction of radiation hazards to aircraft and personnel under attack, etc.

• **Warheads.** This division maintains extremely close liaison with other nuclear agencies to determine future possibilities in warhead development—that is, size, yield, vulnerability to countermeasures, crashes and fires; compatibility with delivery systems, etc.—and to serve as principal USAF information source on these subjects.

• **Human Factors.** Reduction of the possibility for human error in operation of nuclear weapons and delivery systems, including assembly, storage, installation, and other ground support problems.

Directorate of Development mates firepower and machine, develops special supplementary equipment, and provides engineering services to USAF organizations that procure, maintain and use atomic weapons.

The 4925th Test Group (Atomic), consisting of five specialized squadrons, puts much of the rest of the center's work into action. It has delivered all air-dropped nuclear and thermonuclear bombs in AEC's tests since World War II and done the bulk of the cloud tracking and sampling. It operates more than 50 aircraft valued at $90 million and ranging through the most modern USAF equipment. ■

AFAC Sharpens Air Force Armament

Eglin AFB, Fla.—Air Force Armament Center has the mission of developing and testing all of USAF's non-nuclear armament, a task that grows no smaller as the possibility of limited war increases.

As with most Air Research and Development Command centers, having development responsibility does not mean that all the work is done in AFAC's own laboratories and shops. More than two thirds of it is done by outside contractors.

It is AFAC's mission to initiate and supervise research and development, and follow through with testing of the end product. Commander is Maj. Gen. Edward P. Mechling.

Until two years ago AFAC's only job was to test non-nuclear armament. Then functions of Wright Air Development Center's old Armament Laboratory were transferred here, broadening considerably the scope of AFAC's work and its need for testing ranges.

AFAC is a tenant on Air Proving Ground Command's 840-sq. mi. reservation, located on Choctawhatchee Bay on the northwest coast of Florida.

From a small base with a $5 million-budget and some 50 development tasks in 1952, the center has grown to cover 300 development tasks, with an operating and research and development budget of more than $20 million and a civilian and military staff of approximately 2,000.

Ballistics Tables Assigned

Most recent addition to the center's activities is that of developing all USAF firing and bombing tables, including those for nuclear weapons.

AFAC's Ballistics Directorate studies not only ballistics and terminal effects, but explores the fundamentals of blast phenomena, fragmentation, hyper velocity, etc., as they relate to bombs, rockets, gun projectiles and air-launched missiles, in gathering data for its firing tables.

Fire-control and bombing-navigation systems still are developed at Wright Air Development Center, but AFAC has responsibility for providing test ranges and testing equipment for these systems.

AFAC's development and testing activities require a complex of facilities running from the usual gunnery and rocket ranges and firing bays to more elaborate new ranges. Among those recently completed or in the planning stage are:

• **Inertial Systems Range.** Designed for checking out important inertial guidance systems for aircraft and missiles, this range really consists of three ranges—one from Eglin to the Cambridge Research Center at Hanscom Field, Mass., to give a north-south heading; one from Eglin west to Holloman AFB, N. M.; and a third, almost 4,000 miles long, stretching from Mountain Home, Idaho, through the beginning of Air Force Missile Test Center's range at Patrick AFB, Fla., and continuing on to Ramey AFB in Puerto Rico.

• **Joint Range.** Requirement for this range is a ballistic one, stemming from increased versatility of nuclear weapons. USAF, Navy and Atomic Energy Commission are interested in establishing it near existing ranges in the Albuquerque, N. M., area. USAF has said it needs a range 100 mi. long on which to deliver bombs to point of impact.

• **Combined Functions Range.** Increased speeds and ranges of aircraft and of interceptor and bomber-defense missiles have created requirements too great for Eglin's land ranges. Even gravity-dropped bombs have outgrown the 840-sq. mi. reservation, which is dotted with auxiliary AFAC and APG fields.

• **Synthetic Radar Target Range.** Approved and programmed, this range is patterned on a smaller one with which AFAC had success in 1955. The larger range will have a layout of 1,600 radar reflectors which can be arranged to simulate industrial complexes or other similar targets.

• **Damage Potential Range.** Now beginning operation, this range basically is a 2,000 ft. level track which can be used dual or monorail to duplicate speeds of weapons plus speed of the aircraft. Goal is sled speeds of Mach 3.

Some testing will be done with moving targets, some with projectiles fired against stationary targets, to determine interior and exterior ballistics and terminal effects. Fuze testing also will be done here.

AFAC's Air Munitions Development Laboratory, working closely with manufacturers, universities, other services and its neighboring Air Proving Ground, handles development of guns such as revolver cannons and the 20-mm. and 30-mm. General Electric "Vulcan" Gatling cannons, spin-stabilized rockets, rocket guns, ammunition and fuzing.

Armament Test Equipment Laboratory is responsible for proving out the products of development. It must have test instrumentation on the ranges and in working order by the time Armament Laboratory or a contractor is ready to test.

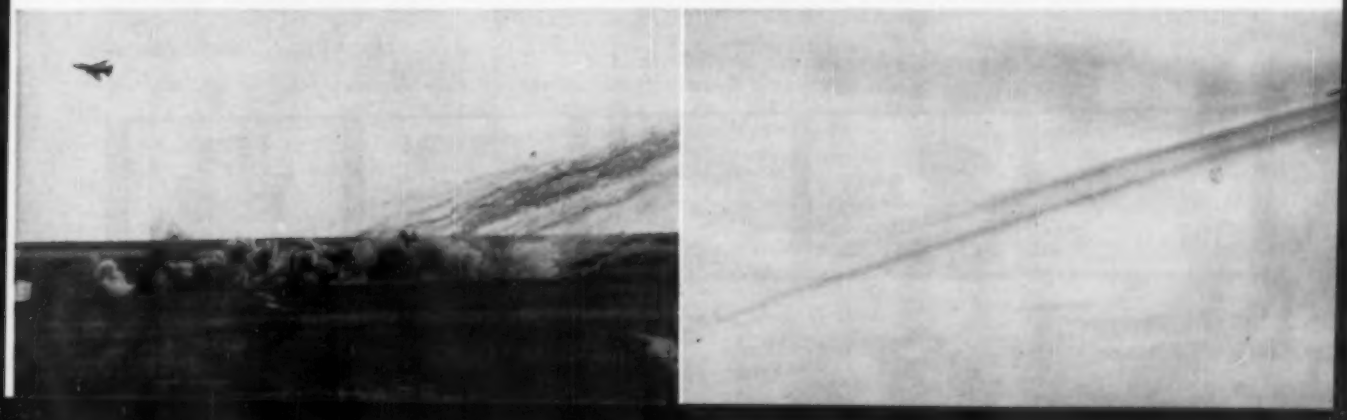
Functions of Directorates

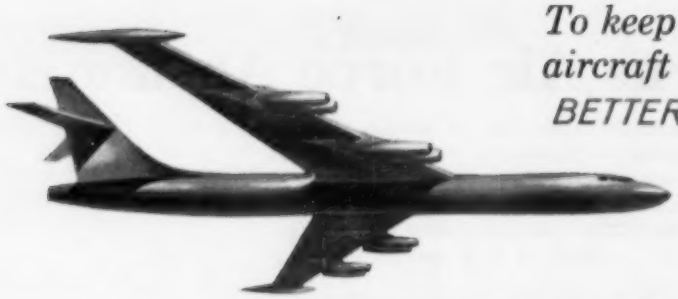
Directorate of Airborne Systems Testing is divided into fire control, bombing and tow target branches. One of AFAC's major efforts is to develop supersonic tow targets and the aircraft to pull them for testing gunnery and rocket capabilities of high-speed aircraft.

Directorate of Munitions Testing is divided into weapons and missiles branch, fuze test branch, and bacteriological and chemical warfare branch, whose mission is to develop "retaliatory capability, both defensive and offensive" in the BW-CW field.

Directorate of Technical Support provides engineering, mathematical and operational services, including such diverse activities as overseeing contractor range operation, conducting data reduction and modification and installation work for test aircraft. ■

F-100 SUPER SABRE fires 114 rockets at tank in test of LAU-3/A rocket launcher at Air Force Armament Center.





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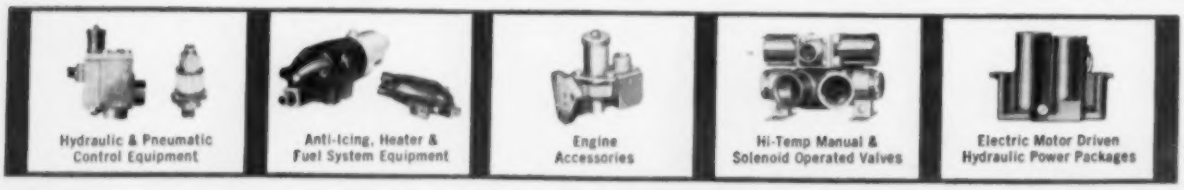
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LOCKHEED X-7 ramjet research vehicle is loaded on truck after recovery in tests at Holloman AFB, N. M.

Arnold Tests Airframe, Engine Designs

Tullahoma, Tenn.—Heart of Air Research and Development Command's pre-flight aerodynamic and propulsion testing facilities is the Arnold Engineering Development Center, a unique ARDC installation both from the technical and the managerial points of view.

Conceived as a part of the government's Unitary Plan to provide wind tunnels aimed at maintaining aeronautical superiority but costing more than industry could pay, Arnold has grown in a way typical of research facilities since World War II—it has been hard put to stay ahead of the advance of technology.

Nevertheless it has contributed since completion of its first tunnel to the nation's most important weapons programs, including Century series fighters, the B-58 supersonic bomber and the intercontinental ballistic missile.

AEDC depends on its operating contractor, ARO, Inc., to a greater degree than even the Air Force Missile Test Center at Patrick AFB, the only other ARDC center which has a similar management arrangement.

Now more than three-fourths completed, Arnold finds that its real value lies in its potential. It is located on a sprawling wartime Army base near a man-made lake that provides a virtually unlimited power source and cooling water supply for its complex of tunnels.

Operated by an industrial contractor and staffed largely with industry-trained personnel, it is well keyed to its primary task of serving private contractors. One former commander has predicted that it will be "the leading aeronautical testing center in the world at some time in the future." ARO's managers point to a more important factor than physical expansion capability attitude of testing personnel.

"You cannot expect men of this caliber to be just service station attendants," Ronald Smelt, Gas Dynamics Facility director, says. "Primarily we are a service station, but we like to think that while we are giving service out front we are working on a hot-rod in back."

One of Arnold's largest problems in servicing competing airframe and engine manufacturers impartially is proprietary data. Elaborate safeguards are set up to protect everything from physical security of a contractor's hardware and documents to test results, which take the form of reduced test data, ARO project engineers' preliminary data reports, final ARO test reports, etc.

While manufacturers never are allowed to share information of other manufacturers, ARO must provide ARDC and Air Force with all test results, so that the best interests of both the competing contractors and the country may be served. The responsibility this imposes on ARO and Air Force is both obvious and enormous.

Priority for use of AEDC's facilities is established by ARDC and USAF headquarters.

Air Force staff at Arnold is organized into two operating divisions, research and development and installation engineering.

Research and Development Division is made up of programs, technical information and intelligence, and plans branches, and has representatives for the Propulsion Wind Tunnel, Engine Test Facility and Gas Dynamics Facility. ■

USAF Sponsors European Research

Brussels, Belgium—Air Force scouts Europe's research talent and maintains contact with its scientific community through Air Research and Development Command's European office here.

Created late in 1952, the office has a staff of some three dozen and no budget of its own—drawing contract funds from ARDC centers at home when they accept research proposals submitted by European scientists or organizations through the Brussels communications channel.

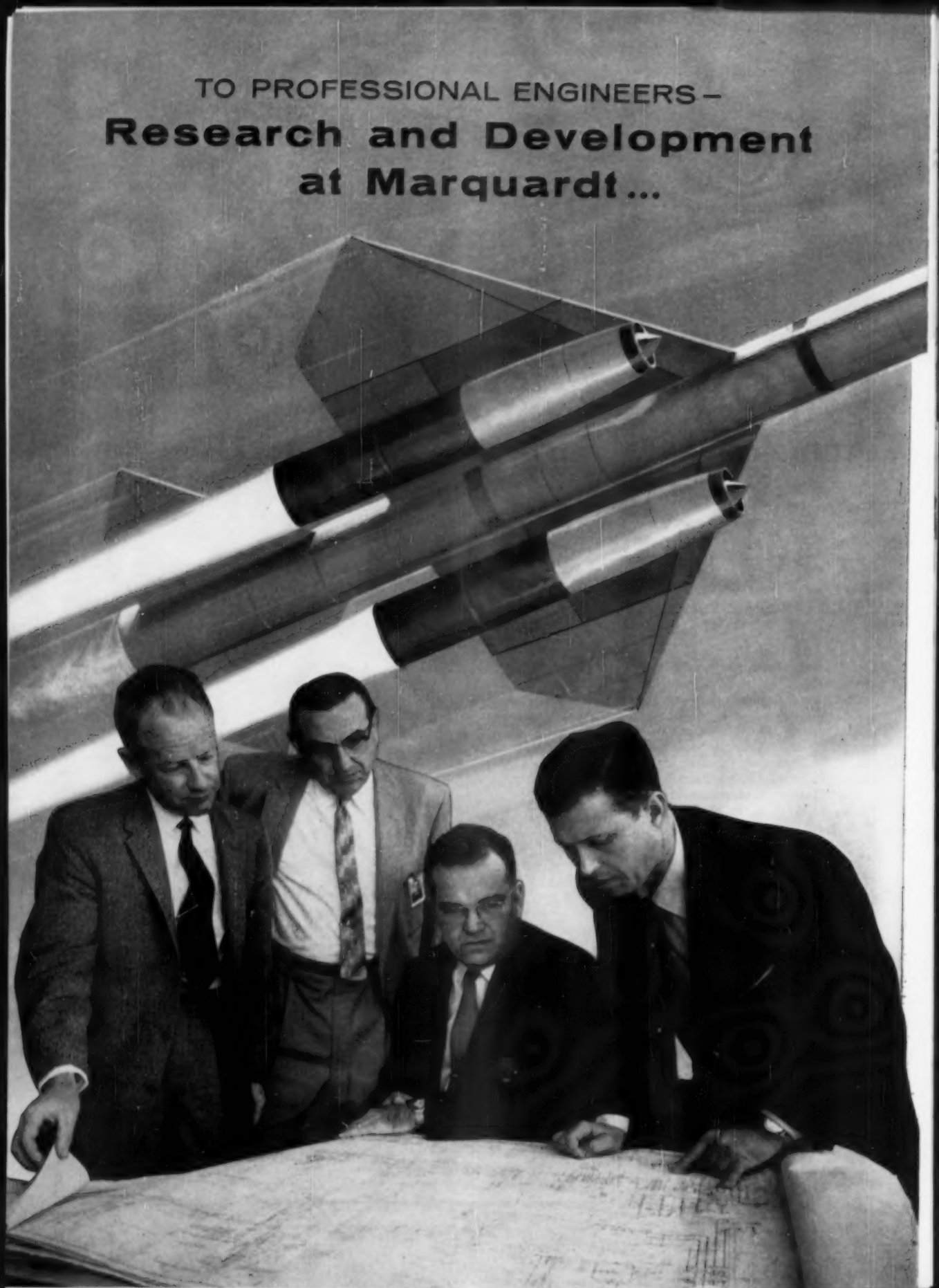
Although the European office does not propose work—preferring initiative to come from the scientist—it maintains close enough liaison with scientists and scientific trends to know where the best technical competence is available. It also advises scientists to steer clear of work already being done in the United States, to avoid duplication.

Universities hold some 64% of the European contracts with ARDC. Industry runs second with 17%, national research institutes next with 16%, and individuals hold 3%.

Contracts range across at least a dozen European countries. Majority, in spite of the devastation of the country's aviation industry during World War II, is with Germany. It outstrips the second-runner, Great Britain, by more than two to one.

TO PROFESSIONAL ENGINEERS –

Research and Development at Marquardt...



Controls–The ram air turbine, a product of accessories research and development, provides auxiliary power for supersonic fighter aircraft, such as the Chance Vought F-8U.

Stimulates Progress in Propulsion and Propulsion Controls

At Marquardt Aircraft, research and development in the critical areas of propulsion and propulsion control is producing a steady stream of improved technology and product. As a result, professional engineers will find a broad range of challenging opportunities in the scientific fronts of these activities.

In propulsion, Marquardt's progress is marked by powerplant applications on the supersonic Bomarc interceptor missile, soon to go into production, and the Lockheed X-7 Test Vehicle. Coincident with this, Marquardt scientists are obtaining a new understanding of the aerodynamic, thermodynamic and chemical behavior characteristics of even more advanced propulsion systems and exotic fuels.

In controls and accessories research and development, Marquardt's pioneering has resulted in projects that are years ahead. From today's ram air auxiliary power applications on the Chance Vought F-8U and the Lockheed F-104 – to tomorrow's Nuclear Powered Aircraft, Marquardt controls and accessories are advancing the state of the art.

Professional engineers are invited to investigate these and the many other challenging research and development projects at Marquardt Aircraft, leader in ramjets – "The Powerplant of the Future." Today is the day to write that letter to Jim Dale, Professional Personnel, 16551 Saticoy Street, Van Nuys, California.

Powerplants–In supersonic powerplants development, Marquardt ramjet engines provide cruising power for the Lockheed X-7 Test Vehicle, and will soon go into quantity production for the Bomarc interceptor missile.

marquardt AIRCRAFT CO.

VAN NUYS, CALIFORNIA OGDEN, UTAH

FIRST IN RAMJETS

Teamwork–A professional engineering team at Marquardt directs advanced projects that reach far into the future...part of this team are the operating Chief Engineers and company President, Roy Marquardt. (L to R) John Winter, Powerplants; Tony Kreiner, Controls; Roy Marquardt; and Leigh Dunn, Test.

Research–Headed by John Drake (inset), Director of Long Range Planning and Research, Marquardt's research scientists and engineers work in modern facilities which provide them with an environment that stimulates free inquiry.

Circle Number 313 on Reader-Service Card

AIRCRAFT { PLASTICS METALS

DESIGN - DEVELOPMENT - FABRICATION

The Brunswick-equipped McDonnell Voodoo

This 5½ foot boresight radome for the McDonnell Voodoo features extremely close tolerances and superior electrical performance.

Advanced techniques and facilities in the areas of reinforced plastics, metal honeycomb and conventional metalwork have made Brunswick a prime supplier to the nation's leading airframe manufacturers. Whatever the problem, whatever the materials . . . a discussion with Brunswick could prove valuable to you. Write or call: The Brunswick-Balke-Collender Company, 623 South Wabash Ave., Chicago 5, Illinois: WAbash 2-4020.

BRUNSWICK

Circle Number 309 on Reader-Service Card

LIQUID FUEL rocket test sled at Air Force Flight Test Center produces 50,000 lb. thrust for 4½ sec.

Cambridge Advances Art of Air War

Hanscom Field, Mass.—Air Force Cambridge Research Center's Electronics Research Directorate (ERD) bears a striking similarity to Bell Telephone Laboratories in the broad scope of its activities and in the specific programs to which it devotes the bulk of its efforts.

A few of the similarities are:

• **Activities** range from basic research for new knowledge and component development to the design of complex systems.

• **Major emphasis** is on digital communications and data processing.

• **Large number of** PhD's and scientists engaged in basic research.

Nearly every ERD laboratory has a direct counterpart in BTL, but there is one major difference. BTL's efforts are pointed primarily toward advancing the state of the communications art. ERD's are aimed at advancing the art of aerial warfare.

In its earlier years, ERD tended to specialize more in basic research into new techniques while Rome Air Development Center specialized in specific equipment development.

The fact that much of ERD's research was in digital communication and data processing and the fact that these techniques now form the vital nervous systems of all the new complex ground supporting systems for air defense and tactical air control, have pushed ERD into the hardware development area. Typical systems include BADGE (Bomber Air Defense Ground Environment) and TACS (Tactical Air Control System) as well as the SAGE air defense system.

A brief description of each of ERD's major laboratories gives an indication of the scope of its total activities:

• **Propagation laboratory** efforts are largely devoted to basic research to gain a better understanding of the characteristics of the medium in which electro-magnetic radiation operates and how these properties affect radio and radar propagation. This laboratory did much of the pioneer work in the field of scatter communications and currently is investigating other promising phenomena including such things as "whistlers," the "dawn chorus" and radio astronomy.

• **Components and Techniques Laboratory** efforts include much basic research into new materials for semiconductor and magnetic devices. This laboratory's activities embrace a variety of scientific disciplines, including chemistry, physics, optics, electronics and combinations of these disciplines.

• **Components and Techniques Laboratory** projects range from cryptography to digital communications, from IFF (identification friend or foe) to various types of voice communications. A major goal of this laboratory is to develop techniques for squeezing more communications into less of the radio spectrum and to increase reliability.

• **Antenna Laboratory** seeks new approaches to the design of radar and radio antennas, both ground-based and airborne. Considerable effort is going into the development of new techniques for making flush-type airborne radar antennas capable of scanning without physical rotation of the antenna itself. The efforts of the Antenna Laboratory are closely allied to those of the Propagation and Communications Laboratories.

• **Radar Laboratory** seeks new techniques for extending the range and definition of ground-based radar and to make it less susceptible to enemy countermeasures. Another phase of its efforts are devoted to techniques and components for three-dimensional radar, capable of providing information on aircraft bearing, range and altitude.

• **Computer Laboratory** is responsible for developing new computer and data processing techniques for application to AFCRC's major electronic supporting system programs, such as BADGE and TACS. It also sponsors state of the art developments in new computer components and packaging techniques.

• **Navigation Laboratory,** which developed the now-famous Volscan airport approach scheduling computer, is working on a number of other traffic control projects for USAF which also may find Common System Application. ■

GRD Explores USAF's Arena

Geophysics Research Directorate of the Air Force Cambridge Research Center has perhaps the largest concentration of scientific talent devoted to exploring the vast four-dimensional region extending outward from the earth, through the changing atmosphere to unknown limits in the space beyond.

Directorate's mission covers solar physics, space physics, ionospheric physics, atmospheric physics, meteorology, micro-meteorology, geodesy, geomagnetism and other terrestrial sciences.

Organization of the 450 people who form the directorate is aimed at keeping expert scientists not only in the laboratory but in key administrative posts.

One large current program is firing of upper atmosphere research rockets at Ft. Churchill, Canada, and elsewhere for International Geophysical Year.

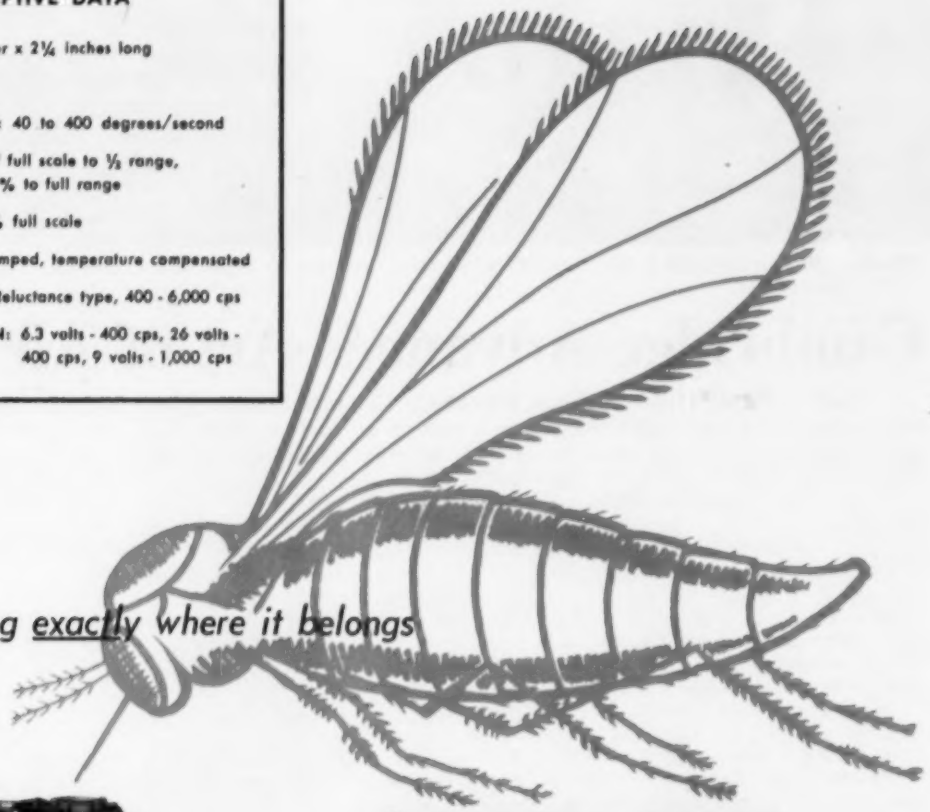
Research rockets used by GRD include the 150-lb. payload Aerobee-Hi, Nike-Deacon, Cajun, Rockaire—which is fired from a fighter in a vertical pull-up—and some balloon launched rockets.

Other projects cover study of contrails and contrail suppression, ozone concentration, ionospheric shape and structure, weather control.

DESCRIPTIVE DATA

- **SIZE:** 1 inch diameter x 2¼ inches long
- **WEIGHT:** 3.8 ozs.
- **FULL SCALE RANGE:** 40 to 400 degrees/second
- **LINEARITY:** 0.1% of full scale to ⅓ range, within 2% to full range
- **RESOLUTION:** 0.01% full scale
- **DAMPING:** Fluid damped, temperature compensated
- **PICKOFF:** Variable Reluctance type, 400 - 6,000 cps
- **MOTOR EXCITATION:** 6.3 volts - 400 cps, 26 volts - 400 cps, 9 volts - 1,000 cps

Putting the sting exactly where it belongs



Gnat Rate Gyro
Shown actual size

GOLDEN GNAT

Miniature Rate Gyros for Missiles and Aircraft

Here is a precision, minature rate gyro. It's tiny . . . measures only 1 inch in diameter and 2¼ inches in length. It's rugged . . . withstands 100G shock and 10G vibration to 2,000 cps. It has a record of proven performance.

Even under the most severe environmental conditions the Golden Gnat will perform as required. To make this possible many unique design details have been incorporated. One such detail is the Gnat's *gold plated* steel housing for improved corrosion resistance and positive hermetic sealing.

Wherever the need exists for high performance miniature rate gyros such as for autopilot stabilization in missiles and aircraft, antenna stabilization and fire control applications, the Golden Gnat is ideally suited. Write for Bulletin GN . . . Minneapolis-Honeywell, Boston Division, Dept AW, 1400 Soldiers Field Road, Boston 35, Mass.

MINNEAPOLIS **Honeywell** H

BOSTON DIVISION

Circle Number 263 on Reader-Service Card

HADC Plays Key Missile Test Role

Holloman AFB, N. M.—ARDC's Holloman Air Development Center's new approach to missile testing, expected to be in operation next year, will feature a "real-time" closed-loop performance analysis system.

System will reduce the number of flight tests required to obtain desired engineering information. It will also permit extension of missile flights into regions of uncertainty without immediate loss of the weapon. Cost will approximate $8 million.

Project was planned by Directorate of Research and Development which sponsors research and development in missile systems and lends scientific support to contractors whose missiles are being tested at Holloman.

Also conducting missile test at HADC, under command of Maj. Gen. Leighton I. Davis, are Directorate of Ballistic Missile Test and Directorate of Aircraft Missile Test.

Among major contractors now testing at Holloman are Douglas, Bell, Lockheed, Goodyear, Aerojet, Martin, Ryan, McDonnell and Convair. Center relies on industry for missile design and fabrication; uses its facilities only to test and evaluate.

MODEL of world's largest solar furnace, which will be completed by 1959 at Holloman.

Other Test Facilities

Other Holloman test facilities in various stages of completion include the 35,000-ft. captive missile test track on which missiles and missile components can be sled-carried to eliminate "bugs" before actual firings; captive-missile test stands which will reveal system defects in a relatively inexpensive procedure which does not expend the missile; a solar furnace to create very high temperature conditions in the range of 6,000-8,000 deg. F.

Center currently is using an elaborate analog computer system and flight simulation equipment for support of missile testing in the preliminary ground phase. Design studies are checked by analog computer and actual hardware is checked by physical simulation equipment.

By comparison, the "real-time" feature of the new system is that computer analysis of missile performance is conducted rapidly while the missile is in flight.

This feature, plus the closed-loop capability, is nearly equivalent to "putting a man in the missile."

This approach to missile testing will require test engineers to devote much greater effort to test planning. Preflight test requirements also will be increased to provide the more accurate and extensive data needed for test planning.

Closed-loop performance analysis system will receive flight test information from missile telemetering equipment and ground instrumentation such as radar and other tracking devices. This will be converted and transformed by computer equipment.

The test track, scheduled for completion this year, will be an extension of Holloman's 3,500-ft. track. It will be a test tool on which shock and accelerations experienced in actual launchings and velocities attained in free flight can be duplicated by sled runs, reducing the costly and time-consuming firing of individual missiles. The 35,000-ft. stretch will permit longer periods of data recording at speeds considerably higher than those attainable on shorter tracks.

Initially it is expected that speeds between Mach 3 and 4 will be attained, and accelerations up to 50Gs. Studies of effects of decelerations in excess of 200Gs are planned. At first track will not be used for firing sled-mounted missiles, but captive firings are planned for the future.

To test large ballistic missiles, four static test stands are being constructed at Holloman. Missile, held captive in the stand, will be operated as if it were being launched for free flight. All missile equipment can be checked in such a static firing. Structure can also be checked for resistance to shock.

Directorate of Aircraft Missile Test conducts development testing of guided missiles.

This includes:

• **Missile countermeasure studies.** Evaluating missile's vulnerability to countermeasure techniques and reporting on jamming susceptibility.

• **Recovery system development.** Creates techniques and equipment for recovery of airborne recording units or even complete missiles.

• **Propulsion services.** Stores and handles unconventional rocket fuels; services and inspects solid and liquid missile propellant systems.

• **Photographic services.** Furnishes documentary record of the missile.

Main workload of the Directorate of Aircraft Missile Test is carried by three divisions: Air Defense, responsible for Falcon air-to-air missile, Talos surface-to-air and Sidewinder air-to-air; Bombardment, with responsibility for both air-breathing and rocket-powered bombardment-type missiles; Drone Systems, testing supersonic experimental target drones.

Two Roles

Holloman is confronted with two roles:

• **Speeding development** of the missile and "selling" it to the operational command.

• **Taking a critical** view of the missile and its value as a military weapon.

This somewhat contradictory situation has been handled by relieving project officer of responsibility of writing evaluation reports on missile progress. Evaluation responsibility is discharged by another organizational element which gathers progress data from the contractor and project officer. Their critical evaluation reports are submitted to Hq., ARDC, and to the weapon system project officers.

Study of human factors in aviation is conducted by the Aero Medical Field Laboratory, under the Directorate of Research and Development. ■

NOW...

before production, during development—

design LIGHTNING-STRIKE PROTECTION into avionic equipment!

DALE PRODUCTS, INC. offers the first commercially available LIGHTNING and TRANSIENT VOLTAGE RESEARCH and TESTING LABORATORY

Never before have such testing services been readily available on a commercial sub-contracting basis; able to provide specific answers to problems relative to lightning strikes on electronic apparatus and equipment.

From time to time every major aviation company has either faced long delays or had to accept equipment without complete high voltage simulated lightning tests being conducted.

Acceptance of such untested equipment is no longer necessary. Delay from waiting on such testing need not hinder your production and delivery schedules.

Testing your equipment on a sub-contracting basis is immediately possible at the Nation's first commercially available lightning and transient voltage testing laboratory.

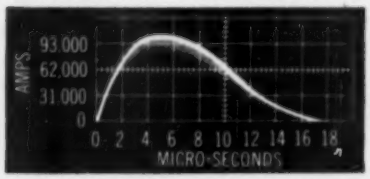
Taking over five years to conceive, this new Dale Products, Inc. testing facility allows conducting stroke current and capacitor explosion tests in accordance with MIL-A-9094B(ASG) and MIL-M-25160(USAF).

Lightning strike effects on many varieties of electrical and electronic apparatus such as aircraft and missile antennas, UHF equipment, lightning arrestors and other allied types of transmission gear can now be conducted to your specific order.

NEW LABORATORY PROVIDES
three separate surge circuits to simulate lightning strike effects on avionic equipment

The Dale Products, Inc. Lightning and Transient Voltage Research and Testing Laboratory has complete facilities for conducting extensive and thorough tests of simulated lightning effects on a sub-contract basis.

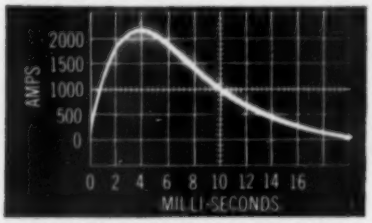
CIRCUIT A
Total charge of 1 coulomb. Total power is 50,000 watt-seconds. Low inductive circuit with 10 micro-farads capacitance, charged to 110 KV.



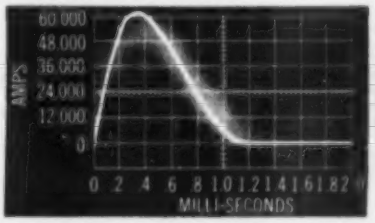
Wave form conforming to MIL-A-9094B(ASG) stroke and capacitor explosion tests. With series resistance, rise time is 5 micro-seconds at 100,000 amps.

Fluctuating wave form, no series resistance, with peak current in excess of 150,000 amps at 10 micro-seconds.

CIRCUIT B
Total charge of 25 coulombs, total power is 50,000 watt-seconds. Low inductive circuit with 5000 micro-farads capacitance, charged to 5 KV.

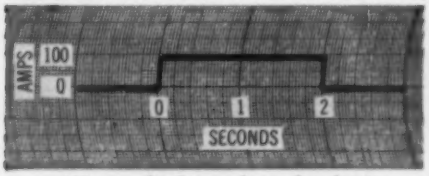


Peak current in excess of 2000 amps with rise time of less than 4 milli-seconds, conforming to MIL-A-9094B(ASG).

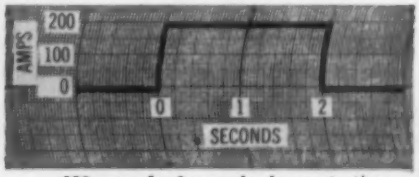


Wave form with peak current in excess of 60,000 amps with rise time of .3 milli-seconds.

CIRCUIT C
Total charge of 400 coulombs. Series circuit consisting of 360 volts, rated at 100 amp/hours.



100 amps for 2 seconds, conforming to MIL-A-9094B(ASG).



200 amps for 2 seconds, demonstrating some of the flexibility of this circuit.

The above oscillographs represent some of the wave forms obtainable from this new facility. Wave forms to conform to your most demanding requirements can be established.

In conjunction with stroke and capacitor explosion tests, supplementary testing such as determining RF characteristics under extremely high altitude, DC corona tests up to 200,000 volts, etc. can be conducted.

Adequate equipment, precision instrumentation and consulting experience makes the Dale Products, Inc. Lightning and Transient Voltage Laboratory of immediate value to advanced avionic research and development programs.

For more details send for descriptive bulletin R-40.

Circle Number 264 on Reader-Service Card

DALE PRODUCTS, INC.
1364 28th Avenue
COLUMBUS, NEBRASKA

Mfrs. of DALOHM Ω resistors and potentiometers, electro-mechanical and electronic assemblies, lightning arrestors and aircraft antenna and antenna masts.

Aerial Warfare Reshapes Rome's Task

Rome, New York—Changing nature of aerial warfare is changing the complexion of Rome Air Development Center activities in the field of ground-based avionics. For example:

• **Global nature of USAF's operations,** demanding speedy communications between far-flung bases and central control points, is focusing RADC efforts on the design and development of a new, improved global communication system.

• **Advent of inertial, doppler, celestial** and other self-contained airborne navigation systems is shifting RADC efforts away from former major activity, ground-based navigation systems, into the development of ground-based guidance systems for missiles.

• **Serious threat of long-range** ballistic missiles has resulted in a major RADC program for the development of a ballistic missile defense supporting system. Heart of this system is a long-range early warning system, using radar and infrared.

Six Directorates

Rome Air Development Center carries out to its assigned responsibilities in six directorates. Three of these carry out hardware development and design; the others provide important supporting services to the former.

Directorates are:

• **Communications.**
• **Control & Guidance.**
• **Intelligence & Electronic Warfare.**
• **Technical Services.**
• **Flight Test & Instrumentation.**
• **Procurement.**

Radio and teletype communications, the oldest of the electronic arts, has until recently been largely eclipsed by some of its more glamorous offspring, such as radar. Communications has not in the past received the technical or financial support accorded to radar, fire control, missile guidance.

The advent of supersonic weapon carriers, coupled with the United States' sprawling global commitments and bases, have forcibly brought home the fact that our communications have failed to keep pace with our needs. It is not unusual for a flight of aircraft to arrive at an overseas base before teletype word of their intended arrival.

A major RADC program calls for the development of a global network of telephone, teletype, radio and facsimile facilities capable of meeting both the day-to-day and emergency needs of the many different USAF commands.

The system must be designed to make efficient use of its facilities, with automatic routing to find the quickest available path to any designation. Further, there must be an automatic priority system which can provide temporary storage of a routine message to free a teletype circuit for a more urgent message.

Another important design criteria is that the system should be constructed from standardized equipment building blocks, not unlike the philosophy of the American Telephone & Telegraph Co.

However, RADC faces a more difficult task than A. T. & T. because its future requirements are ever-changing and far more difficult to predict.

Control & Guidance

Ground-based radar, long an RADC specialty, is being applied to both missile guidance and ICBM defense in the Control and Guidance Directorate. This group's activities also include ground-based navigation aids, such as Navarho and Tacan, secondary radar and IFF (identification, friend or foe) beacons, and the development of automatic approach and landing systems, such as the recently announced Bell Aircraft Corp. system.

Other activities of the Control and Guidance Directorate include:

• **Airport surface detection radar,** or "taxi radar."

• **Ground-controlled intercept computers,** such as the AN/GPA-37, a miniature semi-automatic version of SAGE.

• **EGECON (Electronic Geographic Coordinate Navigation System),** which automatically keeps tabs on each aircraft's position by means of periodic radar transponder messages. Similar devices may find application to Common System traffic control problems.

• **Ground-based radar beacons** for navigation and tactical purposes.

The Radar Laboratory in this directorate is responsible for developing both complete new radars and new radar components, such as tubes, modulators and antennas, as well as new techniques, such as improved moving target indicator (MTI) circuits.

One of the most important tasks of the Radar Laboratory is to develop techniques for making radar less vulnerable to enemy jamming.

Electronic Warfare

RADC holds USAF responsibility for ground-based electronic warfare and has facilities for testing all types of Air Force counter-measures equipment, both ground-based and airborne.

Electronic warfare may take the form of jamming or intercepting the enemy's communications, disrupting or deceiving its radars or other detection devices. One RADC spokesman calls electronic warfare a "never-ending race against time and the enemy's ingenuity."

The human operator plays a prominent role in the design of any ECM equipment because in the final analysis it is a human operator, rather than a radar or radio, who must be deceived or denied the use of his equipment.

Supersonic speeds of aerial warfare demand comparable speed in the collection and dissemination of intelligence data about the enemy, his capabilities and his facilities. Second major function is to develop new techniques for gathering, reducing, storing and handling intelligence information.

This task takes the directorate into a number of seemingly diverse yet functionally related activities.

For example:

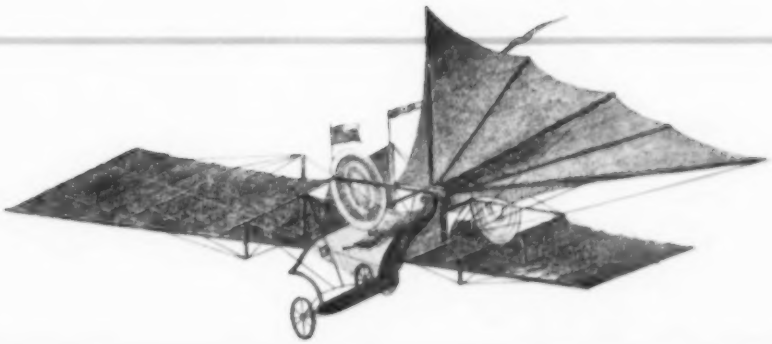
• **Library science:** best data processing and handling system is no better than the indexing system used to classify the information prior to its storage.

• **Automatic translation:** because there are relatively few military and scientific people with a working knowledge of Russian or Chinese, intelligence information can lose much of its value because of delays in translation. For this reason, RADC has a program aimed at development of computers capable of performing semi-automatic language translation. ■

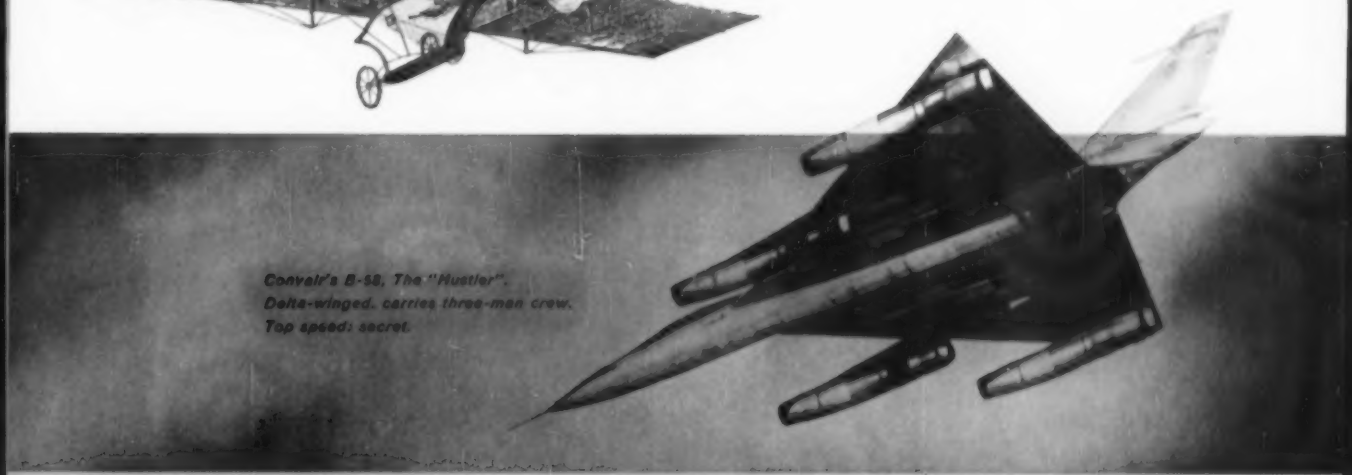
USAF R&D Fund Requirements

Activity	FY 1956 Actual	FY 1957 Estimated	FY 1958 Estimated
Airframes and Their Configurations	$55,696,000	$76,435,000	$58,000,000
Aircraft Propulsion	75,498,437	24,235,000	27,550,000
Aircraft Communications, Navigation, Bombing, Fire-Control Equipment	31,095,000	26,080,000	23,593,000
Aircraft Guns and Launchers	204,000	300,000	0
Other Aircraft Equipment	11,973,000	11,270,000	11,642,000
Aircraft Research	1,547,000	2,473,000	3,032,000
Totals	176,013,437	140,721,000	123,817,000

VIVE LA DIFFÉRENCE



Henson's Aerial Steam Carriage. A model was actually built. Top speed :0— it never flew.



Convair's B-58, The "Hustler". Delta-winged, carries three-man crew. Top speed: secret.

there's a difference in hose assemblies, too!

for example take: FLEX-LIFE INSURANCE

Over three years of successful flight service and millions of feet of installed hose testify to the complete reliability of Fluoroflex-T hose assemblies at temperatures from −100°F to +500°F. Contributing to this remarkable performance, among other things, is the greater flexibility and flex-life of the patented Fluoroflex-T construction. Separate the facts from fable on hose made from Teflon—see the reverse side of this page.

RESISTOFLEX

FLUOROFLEX®-T

hose assemblies

THE VITAL DIFFERENCE

Millions of feet in service ...proof of reliability!

FLUOROFLEX®-T:
Aviation's most advanced hose

The Original fluorocarbon hose

Patented tube compound

Greater flex life

Millions of feet in service

Over three years flying time

Superior impulse life

Leakproof, blowoff-proof fittings

Patented fireproof construction

Self-supporting pre-formed assemblies

Service-proved constructions to 3000 psi

The greater flex-life of Fluoroflex-T hose assemblies is one of many reasons for their outstanding performance and reliability—*proved in over three years of tough, hard service.*

With many times the flex-life of other fluorocarbon hose, Fluoroflex-T assemblies continue to meet the severest requirements even after thousands of flying hours.

Only Fluoroflex-T assemblies provide this safety factor—the minimum insurance which the human lives and costly equipment involved deserve for their protection.

Now, with millions of feet in service, the record speaks for itself. Fluoroflex-T hose assemblies truly insure optimum reliability for aircraft engines, frames and missiles.

VITAL FACTS ABOUT FLUOROFLEX-T

Fluoroflex-T hose is made of DuPont's Teflon®—a *raw material.* The addition of compounding ingredients or the nature of fabricating techniques can vary properties in the end product considerably.

For example, *flex-life can vary a thousandfold* depending upon the manufacturing methods used and the degree of control applied.

Since the properties of products from Teflon can be made to vary greatly, the fabricator's integrity and experience remain the user's best assurance of reliability and performance.

In Fluoroflex-T assemblies, it is the unique patented tube and special manufacturing techniques originated by Resistoflex that make the vital difference.

Resistoflex is the only "coupling manufacturer" that has worked with Teflon since its introduction. If you have any questions on the behaviour of hose made from Teflon, you can get the right answer from Resistoflex — conservatively expressed.

® *Fluoroflex is a Resistoflex trademark. Teflon is a DuPont trademark.*

Originators of high temperature fluorocarbon hose assemblies

Resistoflex
CORPORATION

Roseland, New Jersey • Western Plant: Burbank, Calif. • Southwestern Plant: Dallas, Tex.

Lackland Mates Manpower to Weapons

Lackland AFB, Tex.—Proper classification, training and distribution of USAF human resources to assure that a weapon system becomes fully operational as soon as it is delivered is a major task of the Air Force Personnel and Training Research Center here.

Factor complicating this massive job is that new weapon systems often generate completely new tasks for which there is no training or performance precedent.

Already, weapon systems exist which require as operators men with new personality parameters. The B-58 Hustler supersonic bomber, for instance, requires a pilot with opposite personality poles. Most of the time his duties require him to perform the very monotonous job of watching a number, of dials and indicators, since he has no actual piloting to do. Yet, at the instant of an emergency, he must act with genius to overcome the malfunction. He might be required to hand-fly the plane out of a highly unstable condition.

AFPTRC's job is to help find and train. Problem is that very little is yet known about the subject.

Functions of AFPTRC

AFPTRC is a relatively new center. It was formed early in 1954 by the integration of three previously separate Human Resources Research Agencies within the Air Force's Air Research and Development Command.

The center, whose headquarters are here at Lackland AFB, has three major laboratories—the Personnel Laboratory, also here at Lackland; the Maintenance Laboratory at Lowry AFB, Colo., and the Operator Laboratory, Randolph AFB, Tex.

Other major units are Office for Qualitative Personnel Requirements Information (QPRI) at Lackland, and the Office for Social Science Programs at Randolph.

AFPTRC defines its functions this way: It assembles and develops relevant theory and knowledge necessary for:

- **Developing information** and products for current Air Force personnel operations.
- **Generating specifications** for the Air Force personnel systems of 1960, 1965, 1970, and so on.
- **Participating** in weapon system development.

The center's formal mission is "to improve, through research and development, the effectiveness and efficiency of Air Force personnel operations."

AFPTRC is striving to maximize the effectiveness with which the limited manpower resources of the United States are used through:

- **Determining personnel** requirements of new weapon systems.
- **Improving selection,** classification, assignment of personnel and other aspects of the personnel system.
- **Improving training methods** and devices.
- **Improving teamwork** and organizational effectiveness from the level of individual weapon system crews up through the overall Air Force management structure.
- **Improving methods** for collecting and analyzing human factor elements of intelligence data.

By helping other ARDC centers to anticipate personnel and training problems generated by new weapon systems, AFPTRC will help to minimize training costs and personnel deficiences when new systems are put into operation, avoid time-consuming and expensive equipment retrofits, and improve future personnel training systems.

By helping to solve personnel and training problems associated with existing weapon systems, the center can better present personnel and training systems.

By accomplishing the necessary research in psychology and social sciences, it can initiate radical reductions in the lead time required to develop personnel and training know-how. Goal is to have a pool of information broad enough to permit rapid answering of new questions as they arise.

AFPTRC requires the services of many different skills and professions to accomplish its many-faceted missions. Among them are psychologists, sociologists, electronic engineers, mathematicians and test pilots.

To achieve the best marriage possible of man and machine so that the resulting weapon system may be highly effective, the Air Force also requires the professional help of human engineers and personnel and training psychiatrists.

The human engineer tries to fit the machine to the man. Working with design engineers throughout a weapon system's development cycle, he recommends design characteristics that will make the machine most readily used and easily maintained by the greatest number of people.

The personnel and training psychiatrist works to fit the man to the machine. He develops the best ways of selecting the right men for the specialized jobs at hand and devises new training methods to make it easier and faster to fit the men to the weapon systems.

Qualitative Personnel Requirements Information is one of AFPTRC's most important non-research programs.

QPRI products fall into these two broad categories:

- **Description of job positions.** This involves the actual identification of various tasks and the definition of the tasks. Major part of the job lies in defining them. The essence of QPRI is to organize these tasks and their definitions into meaningful position descriptions to come up with a logical, feasible and solid job structure.
- **Determination of training devices.** This second portion of the QPRI effort follows development of position descriptions. This is necessary because the descriptions are the training course criteria or training area.

Mission of the Office for Social Science Programs is the application of social science knowledge to such problems as teamwork and morale, motivation and leadership, intelligence data collection, target identification survival, escape and evasion, and resistance to interrogation. ■

NEWEST weapon system is Republic F-105B Thunderchief, powered by P&W J75.

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These are history-making accomplishments of major significance in world aeronautical progress. They culminate years of pioneering development by Ryan in the closest technical cooperation with the U.S. Air Force and the U.S. Navy.

By doing the heretofore impossible, Ryan Vertijets point toward an entirely new generation of jet aircraft of increasing capability – in climb, speed and altitude performance.

Those with vision can readily see where this milestone in the science of flight can lead. Ever increasing knowledge of jet VTOL is being unlocked by Ryan and the military services.

The Ryan X-13 Vertijet takes off and lands on a mobile ground service trailer, which can be moved from place to place to meet varying operating conditions. This new system of operation can release high-performance aircraft from dependence upon preparing airports and runways, vulnerable to destruction in time of conflict.

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Long-range equipment to speed schedules, reduce "stacking" and air lane congestion; assure positive air traffic controls—create "more sky to fly in"

Raytheon radar at 23 of the 28 heavily circled areas will be an integral part of C.A.A. control network. Light circles indicate future coverage.

The Civil Aeronautics Administration has just taken a giant step to solve aviation's biggest problem: air traffic control.

New Raytheon radars with huge 40-foot antennas will be a key part of a complex nationwide air surveillance system that follows and helps safeguard all aircraft during every stage of flight. Radar scopes that display air lane maps pinpoint plane positions at distances up to 200 miles, altitudes to 70,000 feet.

These "Flight-Tracker" radars detect and track aircraft in all kinds of weather—even see through storms. A unique indicator tells the operator when the unit needs servicing.

By making possible precise new air traffic patterns, by speeding arrivals and departures, Raytheon radar readies the air lanes for the Jet Age. Here is another instance where Raytheon's "Excellence in Electronics" clears a roadblock from America's path to air progress.

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Edwards Evaluates Weapon Systems

Edwards AFB, Calif.—USAF's Flight Test Center, responsible for the testing of all Air Force aircraft, enters the life of a new weapon system early, with AFFTC personnel sitting in on design evaluations, mockup boards and other judging groups.

Complete evaluation of a new weapon system at Edwards, where all parts come together for the first time, includes an eight-phase test program:

- **Phase I—Contractor compliance** or, will it fly? Aircraft, in about 20 hours of testing, is held to 80% of design limits.
- **Phase II—Initial performance,** usually Phase I done again by USAF pilots.
- **Phase III—Contractor development,** where most major bugs will be ironed out, most of fixes suggested by test pilots will be made.
- **Phase IV—Performance and stability,** in which entire performance regime will be investigated. In some 200 hours, data is obtained from which aircraft handbooks are later written.
- **Phase V—All-weather testing,** done at Wright Air Development Center, Ohio, Eglin AFB, Fla.; Ladd AFB, Alaska.
- **Phase VI—Functional development,** using production models. Every necessary part of the weapon system must be operative; everything in the aircraft's repertoire is accomplished. Using-agency pilots enter the picture here, helping fly this phase, which uses three to six airplanes for about 150 hr. each.
- **Phase VII—Operational suitability,** accomplished by using agencies at the Air Proving Ground.
- **Phase VIII—Unit operational employment testing,** accomplished by using commands under supervision of Air Proving Ground.

AFFTC is located at Edwards on California's Mojave Desert. Its 300,000 acres are around a dry lake bed 13 miles long and 5 miles wide. The lake bed, smooth and hard, is able to withstand the heaviest landing loads and is ideal for deadstick landings and long-run takeoffs. It is the prime reason for the center's location here.

During the past six years more than 400 test missions have been necessarily interrupted with emergency landings on the lake without mishap. An estimated one-third of a billion dollars in aircraft and equipment have been saved.

Along with AFFTC, other tenants of Rogers Dry Lake include the National Advisory Committee for Aeronautics, which maintains a $4 million high speed research station here. Douglas and Convair recently moved into a new joint facility on the edge of the lake.

The need for experimental flight test in maintaining a qualitatively superior Air Force has led to the execution of a $120 million "master plan" at the center. Plan, in which an entire base was relocated across six miles of desert, has involved:

- **Bodily upright transplanting** of a 125-ft.-high water tower.
- **Relocation, intact, of two hangars,** each four stories high and covering more ground than a football field.
- **A new 15,000-ft.** concrete runway.
- **A 142-ft. high control tower,** believed to be the world's tallest.
- **New maintenance hangar** which, with adjoining shops, covers nine acres.

Heart of AFFTC is the Directorate of Flight Test, supported by the divisions of Flight Test Operations, Flight Test Engineering, Technical Services and Technical facilities. Under each division are highly specialized branches. The Project Control Office coordinates the whole directorate.

In addition to the Flight Test Center and Test Pilot School, following are also based at Edwards: 6511th Test Group (Parachute) which is physically located at the NAAS, El Centro, Calif.; 6515th Maintenance Group, which handles upkeep to test airplanes; 6510th Air Base Group, the housekeeping unit for Edwards; Rocket Engine Test Laboratory and Ballistics Test Facility.

Flight Test Engineering Division's branches are performing engineering, concerned with all flying characteristics of an aircraft; Flight Research, which gathers data pertaining to new developments in this aircraft; Flight Development Test, which plans how best to utilize a particular weapon system; Human Factors, concerned with all aspects of the man-machine relationship, in which ground crews and other support personnel are also considered.

In the Flight Test Operations Division are Training and Equipment Office (one for each plane type); Operations and Dispatch Office, Fighter Opera-

BMD Supervises IRBM, ICBM

Los Angeles—Most ambitious weapons development program ever undertaken—creation of a family of intermediate and intercontinental range ballistic missiles—is guided chiefly by the Headquarters, Air Research and Development Command Ballistic Missiles Division.

Known until recently as the Western Development Division of ARDC, the Ballistic Missile Division has two essential partners—the Ballistic Missiles Office of Air Materiel Command and Ramo-Wooldridge Corp.'s Guided Missile Research Division.

BMO monitors some 30 contracts and oversees production, quality control, supply, maintenance and transportation. Ramo-Wooldridge supplies systems engineering and technical direction.

Created only three years ago, the Ballistic Missiles Division now has a streamlined operation holding highest national priority. It is engaged in such rapid development of missiles that test models are fabricated on production tooling.

Division commander, Maj. Gen. Bernard A. Schriever, reports directly to the Commander of ARDC and heads a program from which red tape has been stripped away to a greater degree than any other.

Gen. Schriever told Congress recently that BMD is engaged in a "vast facilities construction program" totaling $400 million, of which $100 million is industry-financed.

First ballistic missile base support squadron has been activated at Camp Cooke, Calif., a former Army site which will be used for training and as the first operational IRBM-ICBM base.

Gen. Schriever told Congress "all major milestones for Thor (IRBM) and Atlas and Titan (ICBM) development have to date been very close to schedule." This includes initial test firings of Thor at Patrick AFB, Fla., and expected firing of Atlas; and powerplant checkouts at Air Force Flight Test Center's Rocket Base.

Major contractors for airframes are Convair Division of General Dynamics Corp. (Atlas); Martin-Denver (Titan) and Douglas Aircraft Co. (Thor).

Major propulsion contractors are Aerojet-General Corp. (Titan), and Rocketdyne Division of North American Aviation, Inc. (Atlas and Thor). Major guidance contractors are AC Electric Division of General Motors Corp., American Bosch Arma Corp., Burroughs Corp.; General Electric Heavy Military Electronics Division; Massachusetts Institute of Technology; Sperry Rand Corp.; Western Electric Co.

Major nose cone contractors are Avco Manufacturing Corp.; Lockheed Aircraft Corp.; General Electric Co.'s Special Defense Projects Department.

Engineering America's Defense

We are very proud to have served some of our country's most important organizations engaged in national defense. The names of a few of them are listed here. Our congratulations to all for a job well done.

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Ordnance Corps

UNITED STATES NAVY
Bureau of Aeronautics
Bureau of Ships
Bureau of Yards and Docks
Office of Naval Research

UNITED STATES AIR FORCE
Air Materiel Command
Air Research and Development Command
Strategic Air Command

INTERNATIONAL COOPERATION ADMINISTRATION

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tions Branch, Bomber Operations Branch, and Cargo and Miscellaneous Branch (which also tests Army planes).

Technical Services Division branches include Powerplant, which analytically evaluates engines involved in test programs; Armament; Photography; Experimental Track Branch, which tests components and systems on a high speed track.

In Technical Facilities Division are branches on Instrumentation; Data Reduction; Telemetering Facilities, handling this operation for both AFFTC and contractors working at the center; Space Positioning Range, which tracks vehicle's path and position throughout various test flights.

Powerplant Branch

Powerplant Branch's main building of 42,000 sq. ft. has 10 bays for engine work plus a machine shop and stands capable of completely testing any engine accessory or component. The branch ordinarily takes a powerplant involved in a test program, works it over, and returns it to the same airframe.

Also recording data on test aircraft is the Space Positioning Branch's Project Range. Instrumentation includes Askania cameras, theodolites, a master target acquisition and control system and a precise electronic timing system.

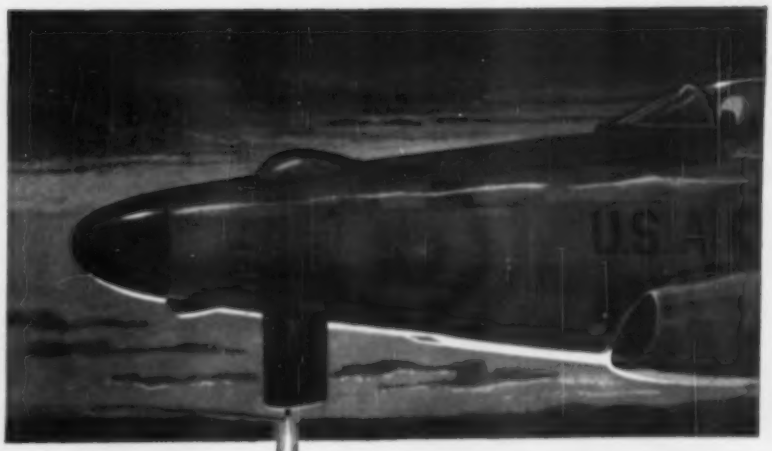
Mission of the Air Force Flight Test School is to turn out pilots fully capable of assessing weapon systems in Phase VI testing and of flying the unusual experimental series of test vehicles.

School teaches the photo panel method of data collection which utilizes Recordaks for frame-by-frame assessments. As the center converts to airborne magnetic tape data recording, school is shifting its training accordingly. The 60 graduates of the four classes a year may stay at Edwards, be assigned to another ARDC center, go to the Air Materiel Command or the Air Proving Ground Command, or be assigned to any other slot in the Air Force where their training and background are needed.

AFFTC's Rocket Engine Test Laboratory, where first sub-systems and components and later complete ICBMs and IRBMs undergo captive flight tests, is located on Leuhaman Ridge across the lake from the main Edwards base.

Three test stands are now being operated by North American Aviation, Inc., Convair Division of General Dynamics Corp., and Douglas Aircraft Co., using powerplants for the rocket-boosted Navaho cruise missile, Atlas ICBM and Thor IRBM.

Four more test stand packages, three missile assembly buildings, and additional warehouse storage facilities are being built or are planned. ■



Kentucky Windage at 650 MPH?

"Kentucky windage" is fine for an oldtime squirrel shooter at 60 yards. But how do you compute cross-wind allowance for high-speed jets aiming at fast-moving flank targets?

The compilation of firing tables required for cross-wind cannon firing is typical of the complex problems facing modern weaponeers. The special abilities of Thieblot Aircraft Company, a division of Vitro Corporation of America, in designing and manufacturing aircraft components and ordnance have made it a key member of the Army-Air Force team working on this difficult ballistics problem.

Thieblot's contribution was the design of a new ballistics data nose. Only a foot longer than conventional fighter noses, it carries a 20 mm. cannon with mount independent of the aircraft motion, four high-speed cameras, radar, and electronic equipment. With auxiliary ground controls this equipment "fixes" projectiles in time and space. This leads to greater protection for bombers and other combat aircraft through more accurate flank fire.

Thieblot Aircraft has also designed purge mat systems for jet trainers, a boundary layer control system, a nose-wheel steering mechanism, an inflight refueling unit, an escape reel for ditched aircraft and other equipment.

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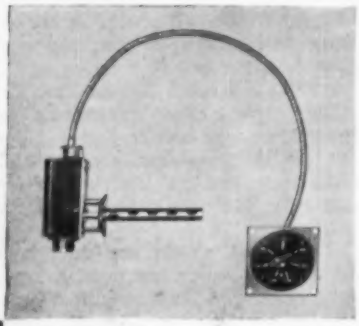

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USAF Sponsors Exploratory Research

Washington—USAF's efforts to acquire scientific knowledge as far as possible ahead of the need for it are spearheaded by the Air Force Office of Scientific Research.

USAF sponsors very little research that could be called basic. Investigations done with no particular goal in mind are left largely to others, while Air Force concentrates on work aimed at gathering data that appears to have some application to concepts or weapon systems of the future.

Mission of AFOSR is to initiate and supervise this exploratory research. The fast pace of technological advancement in weaponry during the past 15 years means that no discipline of science is outside AFOSR's scope of interest. It also means that much of the research work sponsored by AFOSR is quite fundamental, even though it still must be directed as nearly as possible toward USAF's needs.

AFOSR has neither the funds nor the mission to do development work. Instead it must take promising research results and present their potentialities in such a way that other Air Research and Development Command centers, with the task of doing and supervising development—will carry on the work.

As early as 1951, when research and development was placed under a separate command, Air Force recognized that exploratory research was essential if a qualitative lead in weapon systems was to be maintained.

More recently, however, this advanced research has been given an even greater emphasis as hypersonic speeds of missiles and the approaching hypersonic flight of manned aircraft have made it forcibly clear that application is fast outrunning discovery.

This increased emphasis has meant changes for AFOSR:

• **Elevation to center status** in mid-1955 after several years of being shifted around the Air Research and Development Command organization table like a poor relative.

• **Continued, although very gradual,** growth in staff and budget.

From a budget of $14 million in Fiscal 1956—first year of operation as a center—AFOSR went to $16.3 million in Fiscal '57 and is expected to continue at about that level in Fiscal '58.

From USAF's point of view these funds are wisely invested, for two basic reasons:

• **Almost every dollar spent** by AFOSR goes for research contracts. Operating budget is small. Staff has grown slowly from 115 in Fiscal '56 to 119 in Fiscal '57. It is expected to stay about the same in the coming fiscal year.

• **Dollars spent at this end** of the research and development spectrum can mean millions saved later on, by helping to assure success of weapon systems. Comparing the $8 million fly-away cost of a B-52 bomber to AFOSR's yearly budget illustrates the low relative cost of this type of research.

Funds spent on this exploratory research also are spent in a reasonable gamble that some of them will pay off with major technological breakthroughs.

Supporting research is not AFOSR's only task, however. It must be aware of the areas in which research is needed to support present and future USAF objectives, and it must try to know the ultimate value of research findings as soon as they are presented.

Formal mission assigned by Air Force and ARDC are:

• **Plan, initiate and manage** an exploratory research program "to provide new scientific knowledge" that may result in "significant new concepts of air war-

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fare and steady improvement of aerial weapon systems and their use in air warfare."

• **Recognize the implications** and possible application of scientific advances.
• **Recommend to ARDC's commander,** Lt. Gen. Thomas S. Power, policies and procedures that will encourage and stimulate research and "enhance relations with the scientific community."

This last duty is one of the office's most important. Both in fulfilling this and in day-to-day management of its research program, AFOSR is a translator and communicator between Air Force and science, and among scientists themselves.

In its role as communicator, AFOSR contributes to ARDC's long-range planning and plays an important part in the all-important scientific symposia sponsored by the command.

Publications, scientific meetings, frequent visits to university and industry contractors, and the Research Information Office's trend reports and other efforts all provide channels for making Air Force research needs known and for finding the researchers to fill them.

Seven Interest Areas

Rather than divide its present and future work into general USAF requirements or weapon-system concepts, AFOSR organizes scientific interests into seven broad areas that will remain the same while specific pieces of hardware come and go:

• **Atmospheric flight.**
• **Extra-atmospheric flight.**
• **Detection and identification.**
• **Communication and control.**
• **Information handling and analysis.**
• **Target reduction.**
• **Human effectiveness.**

AFOSR's four main scientific directorates are broken down similarly to the classical divisions of the sciences at a university. This eases organizational and communications problems in dealing with universities. These are:

• **Directorate of Bio-Sciences,** with an Aeromedical Division and a Behavioral Sciences Division (including social and psychological sciences).
• **Directorate of Aero Sciences,** with Mechanics, Mathematics and Combustion Dynamics divisions.
• **Directorate of Physical Sciences,** with Physics and Nuclear Physics divisions.
• **Directorate of Material Sciences,** with Chemistry and Solid State Sciences.

The former Office for Advanced Studies at Pasadena, Calif., has been made a Directorate of Advanced Studies. It has a very small staff—eight at present—and its job is what the name implies—advanced thinking and theoretical investigation in the seven areas of scientific interest.

In addition to engaging in advanced

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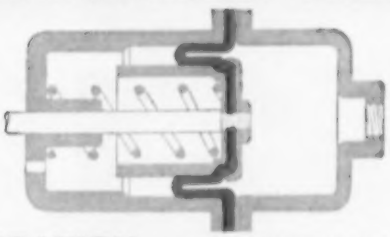

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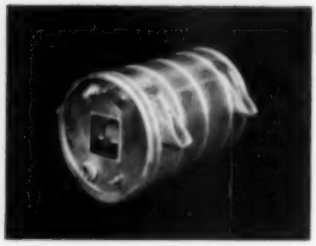
Engineering Beyond the Expected...



DESIGN beyond the expected
The DOVAP prototype (above) is one half the size called for in specifications.

PACKAGING beyond the expected
Shielding of critical areas and equalizing of heat enabled DOVAP to operate at higher temperatures than specified... without benefit of cooling by either conduction or convection.

PERFORMANCE beyond the expected
Where momentary loss of signal means the end of usefulness, DOVAP functioned unfailingly... under environmental conditions of shock and vibration more severe than specified.

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Withstanding torture is a specialty of Packard Bell's Doppler Velocity and Position indicator (DOVAP), designed and developed for an inter-continental missile (classified). In prototype environmental tests, this high powered Doppler Transponder was subjected to temperature, shock and vibration beyond the extremes expected in flight... beyond the extremes called for in specifications.

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studies, the directorate takes results of research sponsored by the science divisions and considers them in the light of USAF's scientific needs and requirements to determine feasibility and practicability of encouraging further research or development of the ideas.

The directorate engages consultants when necessary, and has its own contract program.

Its divisions and the areas on which they concentrate are:

• **Systems Division.** Atmospheric and extra-atmospheric flight.

• **Military Sciences Division.** Strategic and tactical possibilities.

• **Techniques Division.** Detection, identification, communication and control, etc.

Ion Behavior, Free Radicals

Examples of the type of research that the directorate's studies may lead to are current AFOSR investigations of the behavior of free radicals and ions. Both programs, now administered by the Aero Sciences Directorate's Combustion Dynamics Division, began with exploration by the Pasadena office, and both are being done in the hope that the use of free radicals in fuels and the use of ionic propulsion may turn out to be feasible. More contracts for ion behavior research probably will be let in the coming fiscal year.

In addition to the science directorates, AFOSR has a research Information Directorate, with Liaison and Analysis, Presentation and Technical Information and Intelligence divisions; and a Procurement Directorate, broken down into divisions on industrial contracts, university contracts, procurement services and price analysis. This directorate also has a procurement review committee.

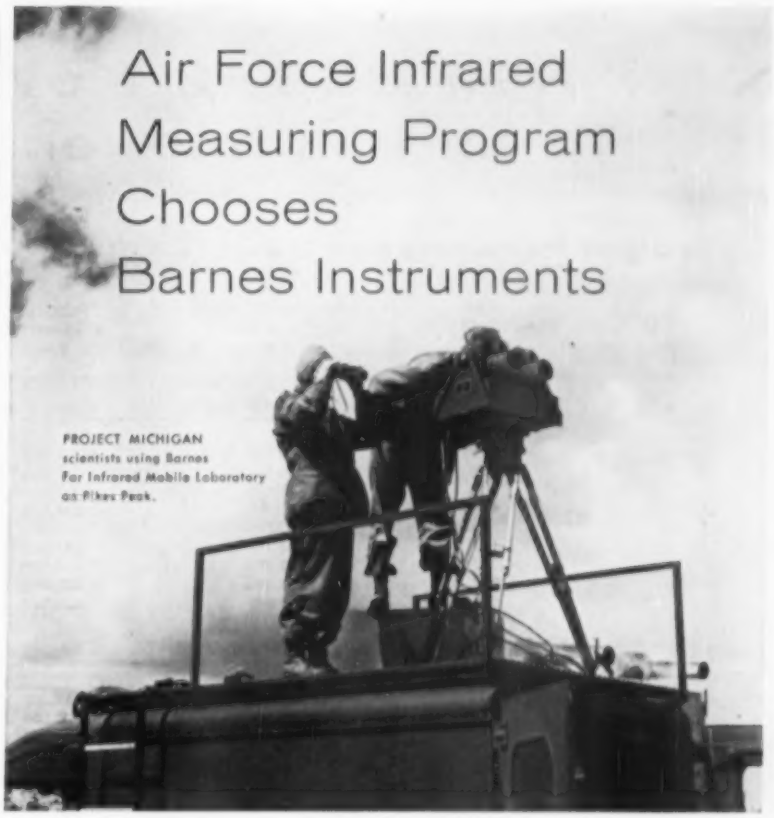
Gen. Gregory also has a Chief of Scientific Research and an Assistant for Medical Research.

Most of AFOSR's work now is with individual investigators, most of whom are connected with universities or research institutes. Contracting with industry is increasing as industry's efforts in exploratory research areas increase, and AFOSR encourages this widening industry participation.

Projects now number about 625. Fewer than 10% are with industrial organizations, although some of those listed for individuals are with employes of industrial firms. Average contract runs about $30,000.

In its attempts to broaden industry's participation in early research, the office has been asking companies to share research costs of AFOSR projects on a reasonable basis.

Brig. Gen. H. F. Gregory, AFOSR commander, says cooperation has been excellent. ■



During September 1956, the Air Force conducted an Infrared Measuring Program (IRMP) atop Pikes Peak, Colorado to obtain much-needed information on infrared radiation of backgrounds and targets.* For this critical pioneering study, the majority of the participating groups selected Barnes infrared measuring equipment.

Barnes equipment used in this program included Infrared Radiometers, OptiTherm* Far Infrared Cameras and low and high temperature Infrared Reference Sources. All of these operated perfectly under severe environmental conditions at 14,000 ft. and −10°C. Barnes Engineering is the only commercial source for completely integrated radiation detecting and measuring instruments of this kind.

The standard line of proven field and laboratory infrared equipment offered by Barnes includes:

Infrared Radiation Measuring Equipment
Infrared Radiation Sources
Thermistor Infrared Detectors
Building Blocks for Infrared Systems

The Infrared group at Barnes Engineering has made significant contributions to the technology and science of infrared radiation detection. Their background and experience are at your disposal—for design and development as well as engineering field services.

Your inquiries will be given our immediate attention.

BARNES ENGINEERING COMPANY, Stamford, Connecticut

*The summer issue of Barnes "Techniques" will report on IRMP and thermal photography. Ask to be put on our complimentary mailing list—on your letterhead, please.

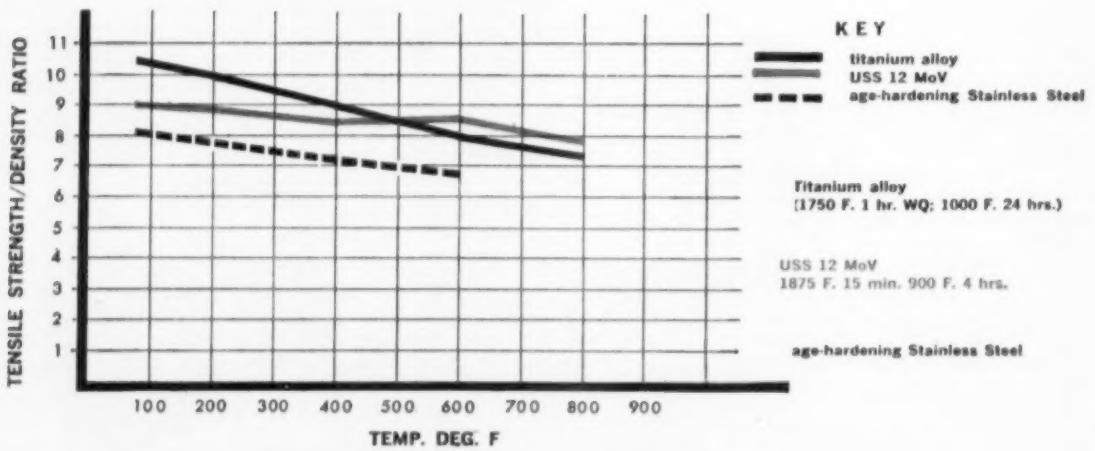
Circle Number 312 on Reader-Service Card

New USS 12 MoV martensitic to an ultimate tensile strength

Typical Performance Data:

TEST TEMPERATURE, F.	YIELD STRENGTH (0.2% OFFSET), PSI	TENSILE STRENGTH, PSI	ELONGATION IN 2 INCHES, PER CENT
	TEMPER 800 F. — 4 hours air-cool		
room	204,200	244,000	—
200	192,500	239,500	11.2
300	183,000	237,750	10.6
400	180,500	236,000	10.5
500	180,000	243,900	10.6
600	173,750	244,500	9.7
700	172,750	239,500	11.5
800	164,000	228,800	10.3
900	158,700	223,500	7.5
	TEMPER 900 F. — 4 hours air-cool		
room	194,700	247,000	—
200	187,250	242,000	12.3
300	184,000	235,000	11.8
400	178,500	231,000	10.3
500	174,500	230,500	10.2
600	173,750	232,000	9.5
700	172,750	229,500	9.9
800	164,250	224,500	9.5
900	164,250	210,250	7.3
1000	142,500	177,500	5.8

Average elevated temperatures tensile properties of 0.10-thick USS 12 MoV previously heat-treated for 15 minutes at 1850° F. and tempered as indicated.



Tensile strength/density ratios for three metals at various temperatures—a comparison between USS 12 MoV, a currently available titanium alloy, and an age-hardening Stainless Steel. Notice superiority of USS 12 MoV at temperatures above 550° F.

steel can be heat-treated of 240,000 psi . . .

230,000 psi guaranteed at room temperature!

In the development of special steels for aircraft use, United States Steel has concentrated on martensitic structures—because they are capable of attaining the highest tensile strength for a given amount of ductility.

USS 12 MoV (Type 422 modified) is one of the most promising steels to result from this program. It can be heat-treated to develop a nominal ultimate tensile strength of 240,000 psi. *Guaranteed minimum tensile strength at room temperature is 230,000 psi.*

Recommended Heat Treatment:

1. Heat for 15 minutes at 1850° F. Air-cool.
2. Temper four hours at a specific temperature within the range of 600°-900° F.
3. Air-cool.

Physical Constants:

Density	.279 lbs./cu. in.
Coef. of Thermal Expansion	7.03 x 10-6/F.*
M_s Temperature	590° F.

*Average expansion over the range R.T. to 1500° F.

Chemical Composition:

C	Cr.	Mo	V
0.20/0.30	12.0	1.0	0.25

Mechanical Properties—Annealed

USS 12 MoV can be furnished with the following typical annealed properties:

Tensile Strength, psi	100,000
Yield Strength, psi	65,000
Elongation, % in 2"	25
Rockwell B	90

After fabrication, following the recommended method of heat treatment, USS 12 MoV can be heat-treated to a minimum guaranteed tensile strength of 230,000 psi at room temperature.

Corrosion Properties:

Like other 12% chromium steels, USS 12 MoV is resistant to atmospheric corrosion in the sense that it does not lose weight. In time it will discolor, or, in certain environments it may develop a light rust film. This will not harm mechanical properties.

Availability:

USS 12 MoV sheets can be produced in the annealed condition in widths up to 48", thicknesses from .015" to under 3/16", stretcher-leveled lengths up to (180") (192") or (196") depending on gage. It may also be produced in a range of plate, bar, strip and wire sizes. Further information on request.

USS 12 MoV is typical of United States Steel research and development efforts to produce aircraft steels of high strength which will maintain this high strength at elevated temperatures along with good corrosion resistance properties. Other special steels for aircraft being developed or manufactured by United States Steel include USS Tenelon Stainless Steel, USS Strux, USS "T-1" Steel, 4130 and 4330.

Watch for further data on these steels in future United States Steel advertisements.

USS Special Aircraft Steels

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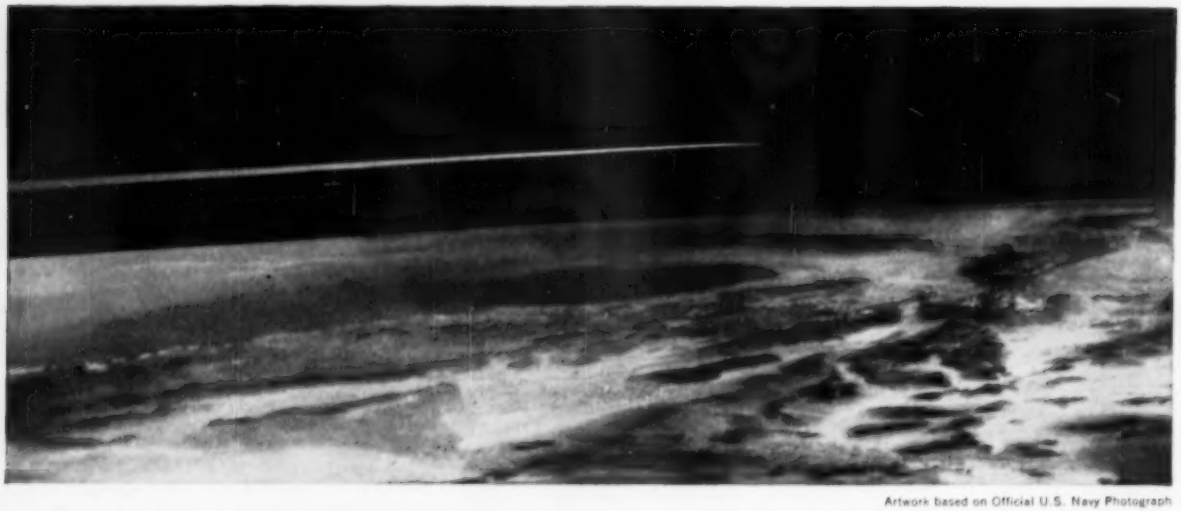
UNITED STATES STEEL

Circle Number 307 on Reader-Service Card

Career News for Engineers!

Flight Tests are under way on one of America's most important defense projects:

The Navaho Strategic Missile



Artwork based on Official U.S. Navy Photograph

The results are secret—but this much can be told. A test vehicle designated the X-10 has gathered new aerodynamic and electronic information which will help to speed progress on the SM-64 Intercontinental Strategic Guided Missile.

The opportunity—and the privilege—to implement this revolutionary data is yours.

Twenty-eight-year-old Army vet **WILLIAM T. SCHLEICH** was graduated from Georgia Tech in 1952 with a BSAE. He joined North American as a junior engineer the same year. Seven months later Bill was promoted to aerodynamics engineer for the Navaho missile program. He was appointed Supervisor, Stability and Control Unit in October of last year. With the help of North American's Educational Refund Plan, he received his MSAE from USC. Bill and his wife are hi-fi enthusiasts and have a sound system built into their Whittier, California home.

If you accept this challenge you'll be solving tomorrow's problems—today. Here facts are collected fresh daily. If yesterday's yield proves inconclusive you'll approach the problem from a new direction. You'll travel new paths and develop new inventiveness. And you'll be guided to each breakthrough by the world's best-informed missile authorities—your own associates.

One example of the new hardware evolving from this creative engineering effort is a fully transistorized electronic commutator. This instrument increases the information-relaying capabilities of the missile's telemetering system by commutating 27 outputs at speeds of approximately 100 cycles per second. It was developed by the Flight Test Instrumentation Group.

North American's Missile Development Division is a major center of missile activity—and a pioneer in the field. As far back as 1948 its first test instrument vehicle was fired from a launching platform. Today North American has complete weapons system responsibility for the Navaho—and its test program is being conducted at the Air Force's long-range missile proving ground which stretches more than 5000 miles across the Caribbean and far into the South Atlantic.

LYLE C. BJORN has lived aviation all of his life. As a high school boy he built a glider modeled after the Wright Bros.' first flying machine—flew it from ski jumps near his Utah home. He studied engineering at Utah State and earned his BSME degree from the U of Wyoming. Lyle joined North American in 1951 and is now Group Leader, Field Test Operations at the Missile Test Facility, Patrick Air Force Base, Florida. He lives with his wife and three children near Cape Canaveral where he is an active leader in Cub Scouts.

If this sounds like the kind of career-opportunity you've been looking for—write us today. We promise you a working climate that stimulates personal growth and rewards it with responsibility, professional recognition and material benefits limited only by your own ability. Further, you can continue to grow academically with the aid of our Educational Refund Plan—and some of the nation's finest universities are nearby.

Let us know what kind of creative engineering interests you. (Please include highlights of your education and experience).

CONTACT: Mr. R. L. Cunningham, Engineering Personnel Manager, Dept. 495-W-6
Missile Development Division, 12214 Lakewood Blvd., Downey, California.

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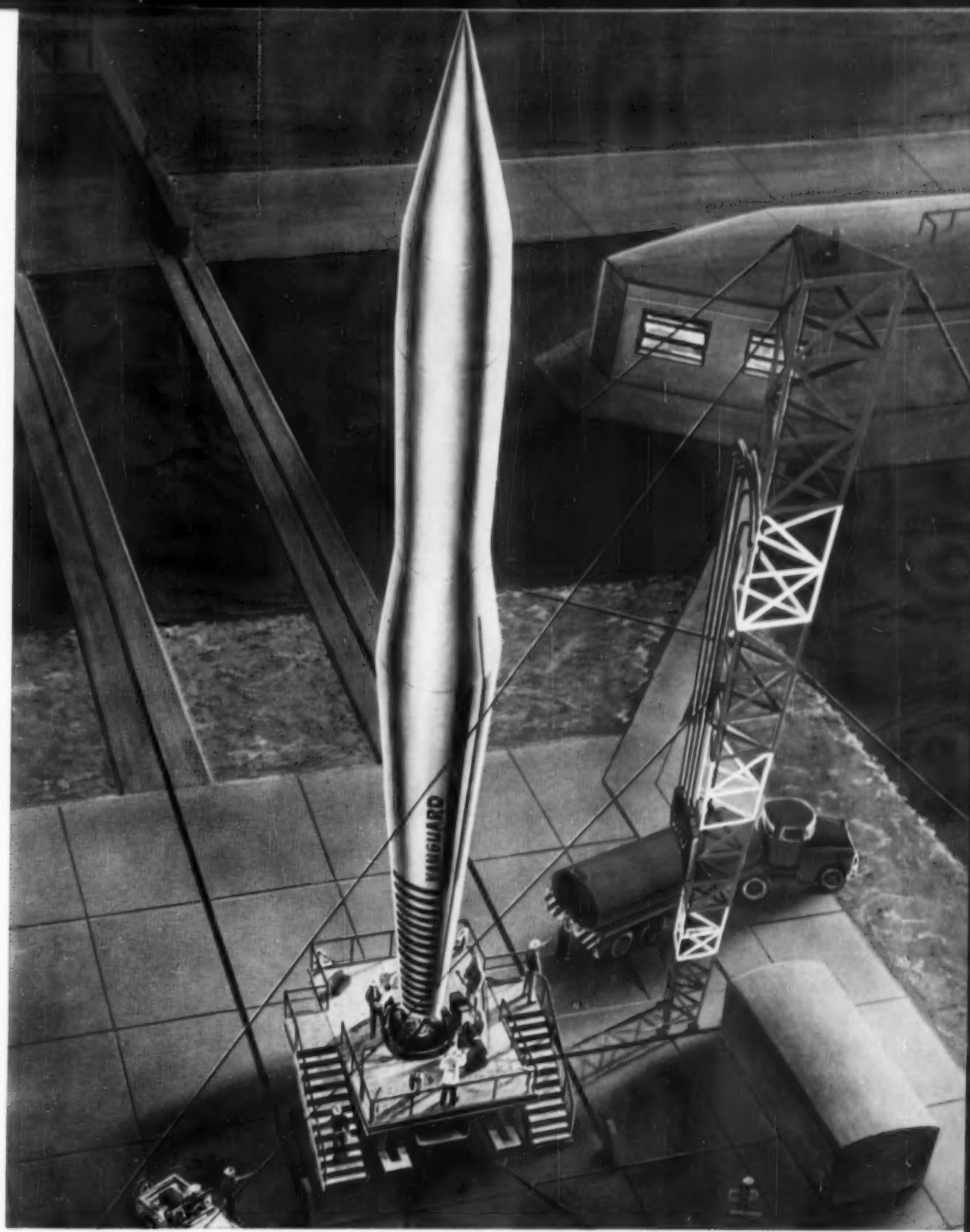

VANGUARD satellite vehicle on launch stand. Artist's drawing by Nick Stanilla of the Martin Co.

Naval Research

CONVAIR 880 jet airliners are scheduled to fly important routes starting in 1959. The 880 is one of more than 40 turbine-powered aircraft types having essential Hamilton Standard equipment. Superior engineering, research, development, and experience stand behind Hamilton Standard's leadership in production for outstanding aircraft—jet or propeller driven.

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HAMILTON STANDARD, WINDSOR LOCKS, CONNECTICUT

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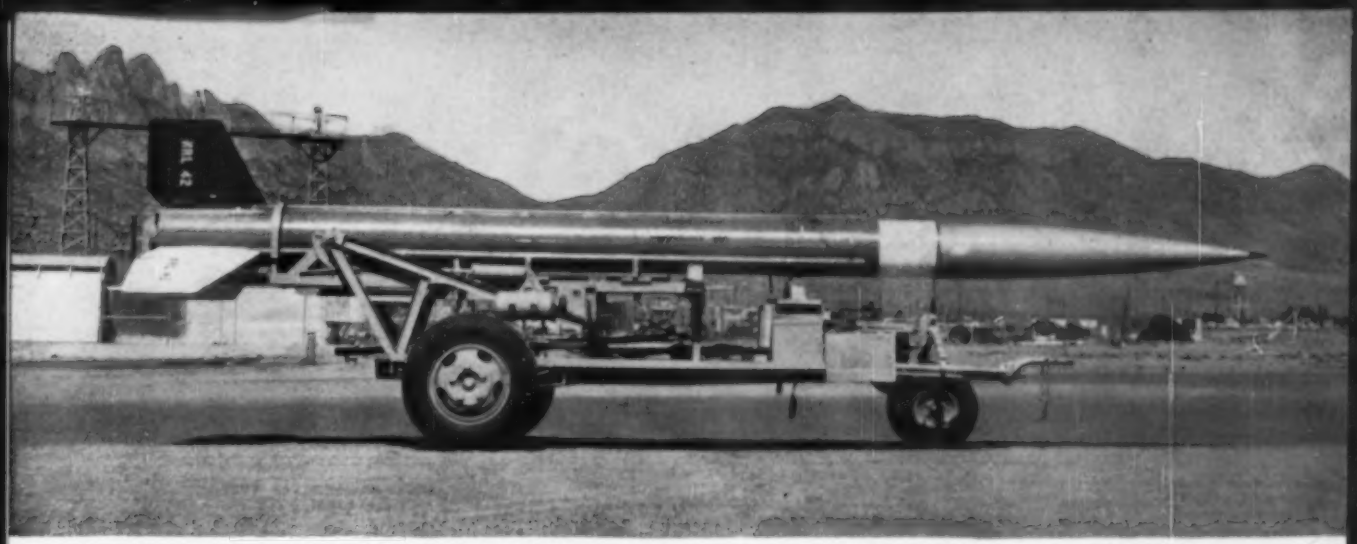


AEROBEE-HI research rocket on dolly is used in Naval Research Laboratory firings at White Sands Proving Grounds, N. M.

Navy Believes Cost of R&D Can Be Cut

Washington—Research and development activity in this country will change drastically within the next few years according to Navy testimony before Congress.

Rising costs, increasing complexity, and ever-widening avenues of possible approach to weapon systems have stirred deep concern among Navy officials as to the economic feasibility of pursuing a "cover-the-whole-field" research and development policy.

Slowdown in Progress

In the recent past, talk of saving money by taking calculated risks with the defense effort would have aroused strong dissent from many members of the Congress. But top Navy officers, appearing recently before the House Appropriations Committee to testify on the Fiscal 1958 budget, predicted a slowdown in technical progress due to a lack of money, and drew no immediate reply from the legislators.

The various Navy bureaus presented requests which already had been substantially reduced by higher Naval authority and the Administration. Navy bureau chiefs also testified that they concurred with the fund slashes—and the underlying concern of every officer who testified seemed to be the need for economy. All of this brought no real objection from the House committee.

Navy Attitude on Costs

This general Navy attitude can not be written off as acquiescence to an economy-minded Congress and Administration.

It is one of the first official manifestations of a Navy belief that scientific, engineering, and managerial skill and experience now are sufficient that the scope of research and development activity can be selectively reduced without endangering the country's defense.

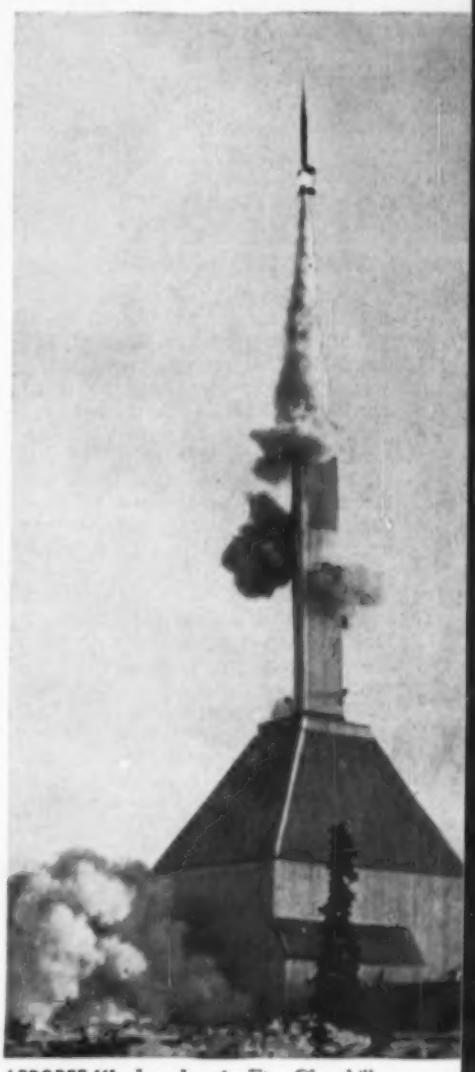
Navy's attitude is best summarized in these excerpts from the hearings:

• **Garrison Norton**, Assistant Secretary for Air: "The increased cost and complexities of the new weapon systems make it mandatory that we choose more carefully than ever before. We can no longer develop nearly everything that looks promising."

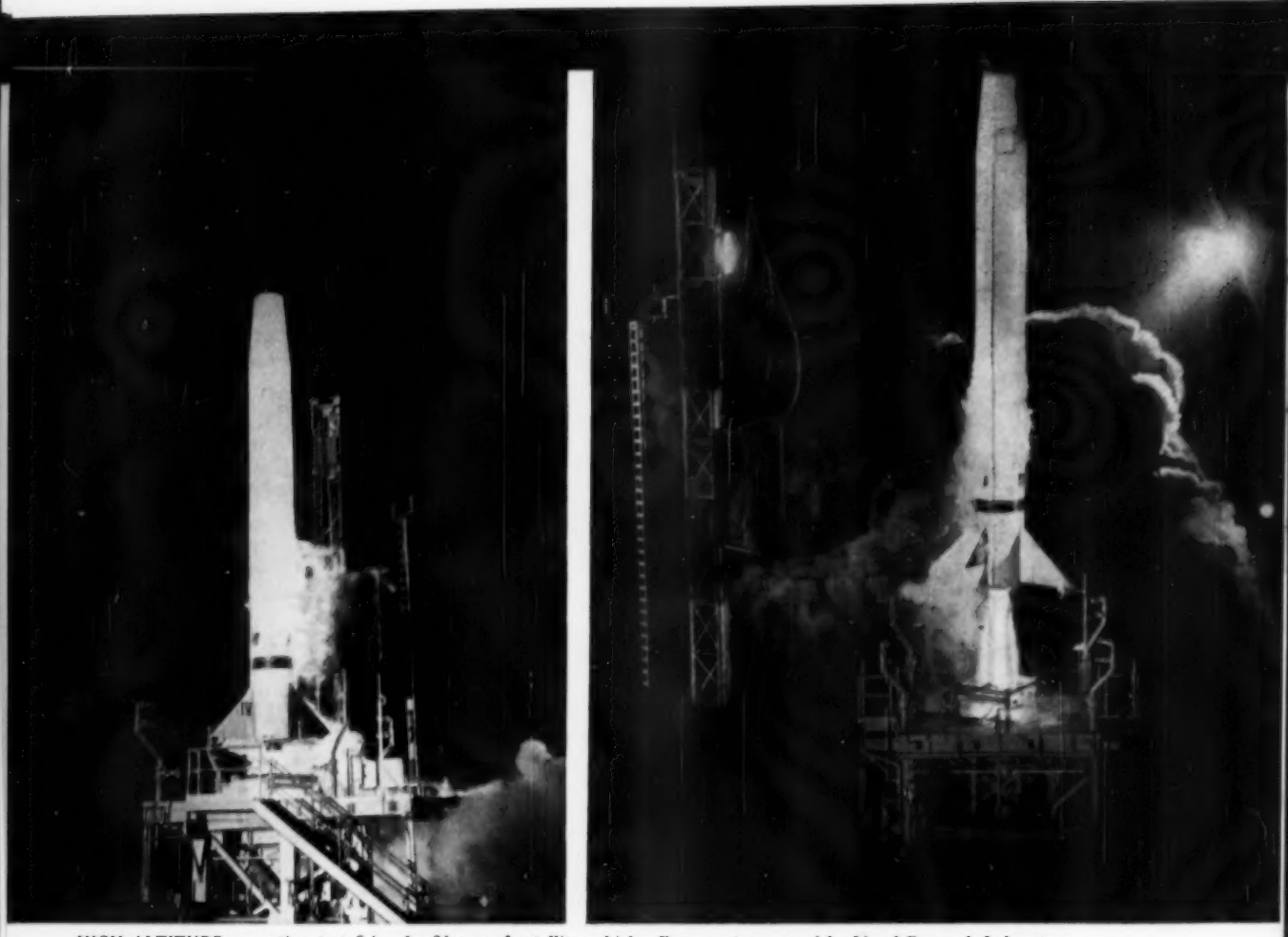
• **Vice Adm. W. V. Davis, Jr.**, Deputy Chief of Naval Operations for Air, in reponse to a question concerning the future level of missile and aircraft procurement: "We see a definite trend toward reaching a sort of plateau in speed and performance, as you run out of usable human directed speeds. The guided missile will undoubtedly replace a lot of interceptor type aircraft. The tremendous technological advances since the war, due to the semi-cold-war status we are in, has brought on this terrific increase, but that is bound in my judgment, to taper off in a very few years to a considerable extent. It will be forced by money, if for no other reason."

• **Rear Adm. Rawson Bennett**, Chief of Naval Research and head of the Office of Naval Research, told the Congressmen that the 1958 research and development program was the most austere the Navy had ever presented. He further explained that this austerity was not readily discernible, since the amount of money his office was requesting was not substantially different from the year before.

"There are basically two reasons for no reduction in funding requests," Adm. Bennett said. "First, the amount of research and development which can be bought for a dollar, second, the complex and inherently expensive character



AEROBEE-HI launch at Ft. Churchill, Canada.



HIGH ALTITUDE separation test firing for Vanguard satellite vehicle. Program is managed by Naval Research Laboratory.

of the work which we must now do."

Adm. Bennett recently has made several statements reflecting his anxiety over the rapidly increasing costs of research and development. He feels it is essentially a joint military-industry responsibility to reduce costs, and that the problem is complicated by the fact that there is a whole generation of engineers in relatively high positions who have never known anything but a cost-plus contract.

Adm. Bennett believes these men and their subordinates must approach their products and services with more of a commercial view, for economy depends to a great extent on their efforts and good judgment.

Perhaps the answer to significant cost reductions is expressed in one of Adm. Bennett's speeches: ". . . We must all do better in a judgment area which is somewhat alien to the American view. We must do better at deciding when something is good enough for the job.

"We cannot go on forever gilding the lily, polishing the chrome, demanding the best, the latest, regardless of the cost when somewhat less will do the job adequately. We do not know whether it is by intent or necessity, but our Russian friends do pretty well at producing things which are good enough."

Intelligent Selectivity

Navy officials spelled out in considerable detail for the House Committee its method of selecting the best research projects for extensive work. This method depends primarily on several committees of prominent scientists and engineers whose parent group is the Naval Research Advisory Committee.

This committee has existed since 1946 but its responsibilities and activities have broadened considerably in the past few years. Its sub-committees currently advise nearly every top Navy official concerning long-range planning problems and technical decisions.

Navy feels, accordings to Asst. Secretary Norton, that its long-range planning ability has increased significantly through the efforts of these committees.

The project NOBSKA committee is a good example of the composition of one of these special committees and the areas of Naval activity that they review. Navy personnel and scientists on the NOBSKA project were assisted by the National Academy of Sciences and National Research Council in conducting a study of undersea warfare.

This group of about 60 people put in about three months of intensive review of the Navy programs in that area and made recommendations for the future.

Inevitable Disagreement

Any public discussion over choosing of a single solution to a weapons requirement while abandoning all others early in the development period has always led to disagreement.

Navy's apparent trend toward decid-

Navy Research and Development

	FY 1956 Actual	FY 1957 Estimate	FY 1958 Estimate
Aircraft and Related Equipment	$148,528,738	$131,369,416	$118,922,000
Guided Missiles and Related Equipment	95,226,874	146,219,035	167,963,000
Totals	$243,755,612	$277,588,451	$286,885,000

LAUNCHINGS are done from Patrick AFB, Fla.

ing on a weapon even before a development period is certain to arouse discussion, even though it is based on the best available judgment and is pursued in the interest of a stable economy.

Navy's firm belief in this economy approach is characterized by Rear Adm. William A. Schoech, Assistant Chief of the Bureau of Aeronautics for Research and Development, whose original request for funds was cut by more than 27% before it even reached the Congress.

Adm. Schoech feels that his office has been allowed enough money to carry on its really essential projects, and that nothing necessary is being neglected. He also has expressed the belief that it is natural for people engaged in research and development to want more money to pursue a wider variety of projects.

There is a meeting ground between what is necessary and what is conceivable, and Adm. Schoech feels that his final monetary request to Congress reaches that meeting ground.

Navy was the first service to create a separate agency to maintain close liaison with and provide financial support for scientific research.

This agency, the Office of Naval Research, was created in 1946 and the success of its operation is reflected in its growth and its emulation by other military departments.

ONR is the Navy's instrument to insure that there is a constant expansion of basic scientific knowledge, which the Navy views as the only guarantee of continuing improvement and growth of Naval weapons.

ONR achieves this by supporting basic research through contracts with universities, industrial laboratories, and Naval facilities. It also coordinates the research and development programs within the Navy Department to prevent overlapping work and to provide a concentrated, coherent program.

Why ONR Was Created

Two factors growing out of World War II were paramount in the Navy's decision to create ONR. First, the extremely long development time required by modern weapons meant that the early and possibly decisive phases of any future war would be fought primarily with arms developed during the decade prior to that war.

Second, the Western European scientific community which provided most of the basic knowledge used in U.S. weapon design before 1940, was all but obliterated and its product largely consumed during the war. It is only now making a large-scale comeback.

These two facts made it clear that positive action on the Navy's part was necessary if the center of scientific endeavor was to shift to the U.S., and the naval weapons of 10 and 20 years after the war were going to be superior items.

Navy then led the way among the services in large-scale financial support of basic scientific research. The combined outlay of money has made it possible for scientists in this country to stay in the forefront in almost every field.

Coordinate Programs

This broad foundation of basic knowledge is the beginning point in the development of all weapons systems. Development programs are initiated by the various Navy bureaus, and the ONR coordinates them to prevent duplication and to advise on feasibility.

Theoretically an ideal management system for development projects, it allows a maximum interchange of ideas, and keeps the people responsible for basic work familiar with development problems so that their effort may be more intelligently directed to usable form.

But it also is a difficult system to keep practically efficient, as it involves many officers and somewhat separated responsibilities concerning programs and their financing.

Navy reported to Congress that it would reach the intended ideal operation of the research and development program it has planned during the next fiscal year.

ONR has been given cognizance over four main types of operation: the contract research program (mainly with universities), the Naval Research Laboratory, two special purpose naval re-

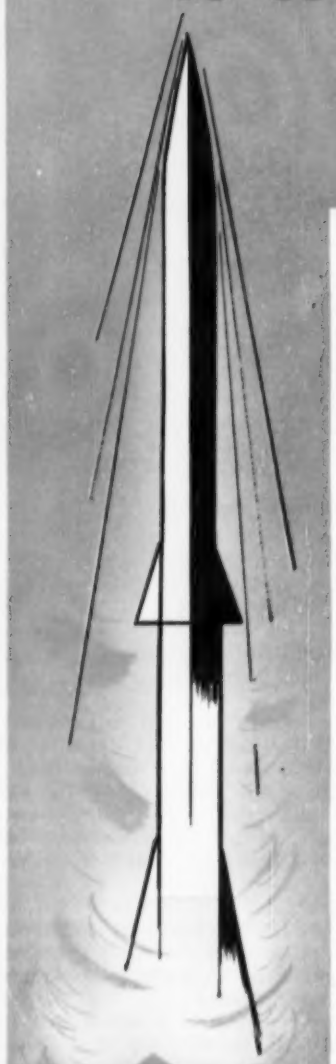
Office of Naval Research—R & D Funds

(New Obligational Authority)

	FY 1956	FY 1957	FY 1958
Aircraft and Related Equipment	$5,026,121	$6,877,000	$5,951,000
Guided Missiles and Related Equipment	1,166,119	975,000	2,147,000
Totals	$6,192,240	$7,852,000	$8,098,000

to users of integrating gyros

AND IF YOUR SYSTEM REQUIRES AN INTEGRATING GYROSCOPE...



It is important that the Gyro be *truly* integrating.

The following are a few basic checks that can be simply made to determine whether the Gyro is a true integrating Gyroscope.

1. With Gyro at null, rotate Gyro about its input axis in a positive (clockwise) direction approximately 50 milliradians.
2. Observe the output voltage and polarity. A true integrating Gyro should show a positive output of a magnitude determined by the product of the angular displacement in milliradians and its rated sensitivity (millivolts/milliradians).
3. The output should remain at this reading providing there is no further input (either angular or command). At this point no drift is being taken into consideration. However, all gyros will drift to a greater or smaller degree. Observe this drift as to direction and magnitude with respect to time.
4. Repeat the above with a negative (counter clockwise) input of approximately 50 milliradians.
5. Observe the output voltage and polarity. A true integrating Gyro will show a negative output equal to the product of angular displacement in milliradians and its rated sensitivity (millivolts/milliradians) and hold this output.
6. If the Gyro tends to return to null in both of the above conditions, it is not a true integrating Gyro.

If you have made the foregoing checks and wish any further information, please call on Greenleaf. It is our sincere desire to provide the utmost in service to Integrating Gyroscope users.

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search and development facilities, and three contractor-operated facilities.

Special purpose facilities are at the Training Devices Center at Sands Point, Long Island, N. Y., and the Underwater Sound Reference Laboratory at Orlando, Fla.

Training Devices Center maintains a staff of about 200 scientists, engineers and technicians to develop the training devices used throughout the Navy. This group has assumed increased importance with the rapidly changing, and extremely complex character of modern weapons.

Their principal function is to develop training devices, evaluate training syllabuses, and to generally reduce training time. The group also initiates procurement after an operational evaluation of new devices.

Sound Reference Laboratory

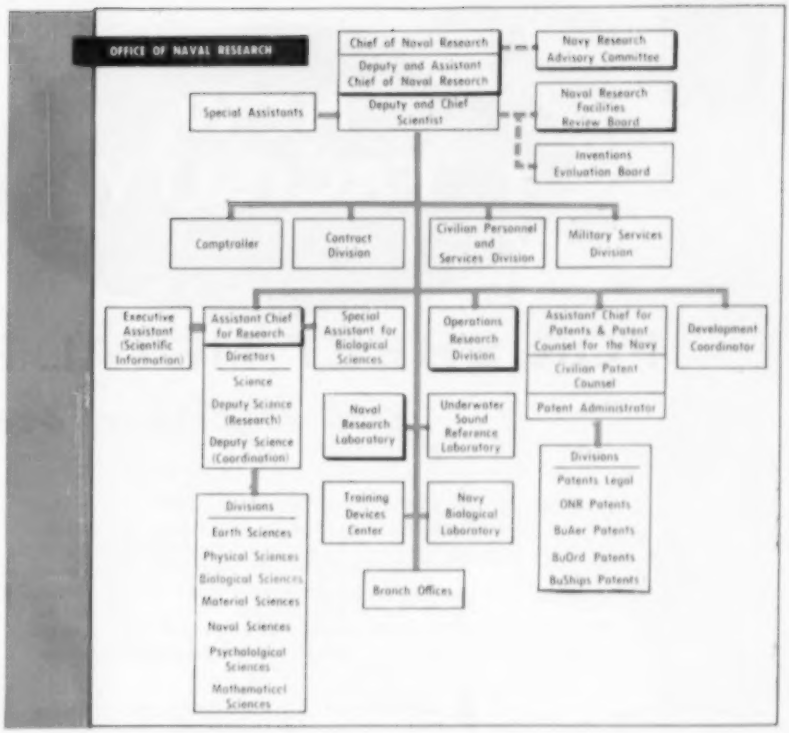
Sound Reference Laboratory at Orlando has the double purpose of developing new sonar and underwater communication and detection equipment and establishing standards by which all underwater sound development work in this country may be compared.

An acoustics calibration division and an electronic engineering division are the foundation of this standardization work. They are supported by the efforts of a research division which works in ultrasonics and low-frequency sound, electronics, and especially transducers.

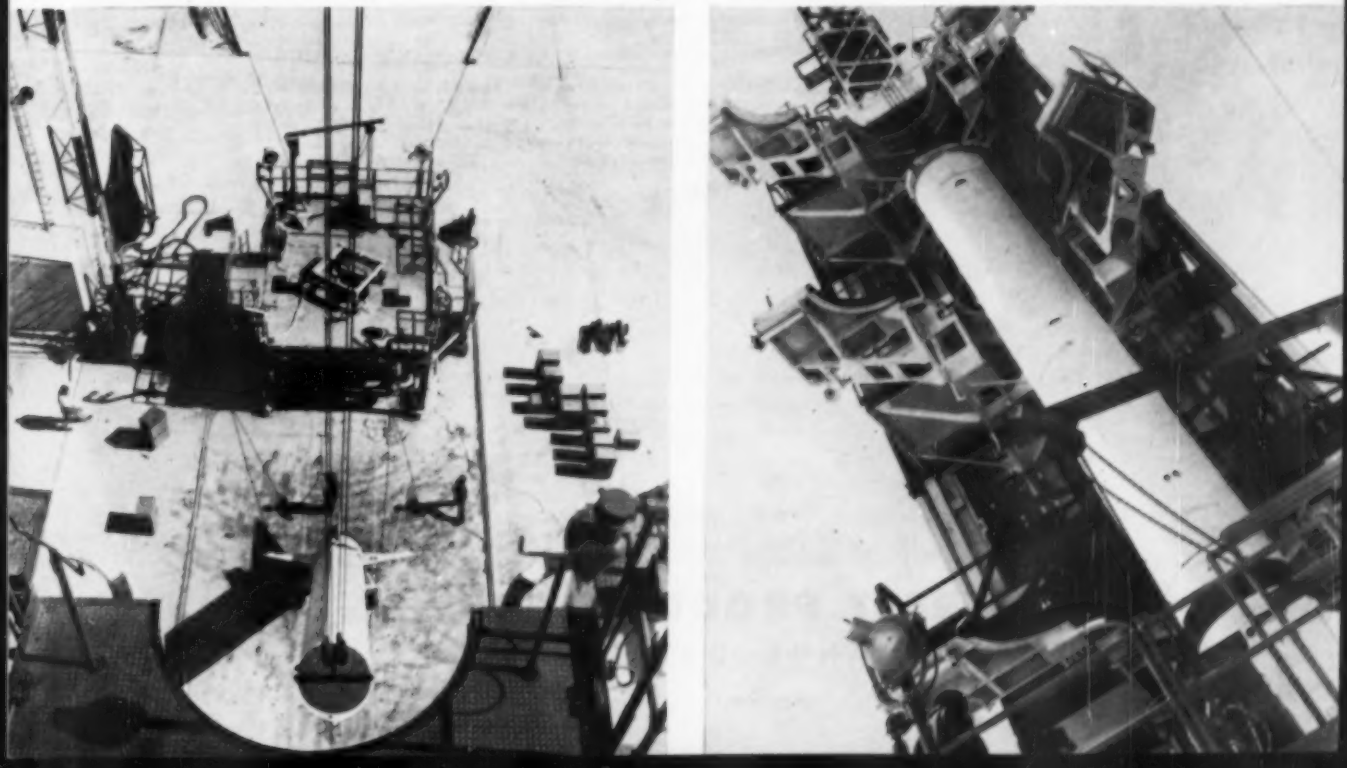
Research centers operated by private contractors for the Navy under the cognizance of ONR are the Arctic Research Laboratory, the Oceanographic Research Laboratory, and the Operations Research Group. The Arctic Research Laboratory has a primary duty of providing basic physical and biological information for the design of new cold weather weapons, equipment, clothing.

Oceanographic Laboratory conducts basic research in all of the various fields of oceanography. It also is active in the development of basic findings towards useful naval applications.

Operations Research Group assesses



VIKING 14, last Navy rocket of its type, is put into launch stand for Vanguard satellite test firing at Patrick AFB, Fla.



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for defense industries

FOREST, OHIO: Sheet metal assemblies of aluminum, stainless steel, titanium and magnesium are being fabricated, inspected and shipped from the new UAP assembly plant at Forest, Ohio. Entering into full-scale operation in March 1957 the new facility is devoted to furnishing sheet metal assemblies and components to aircraft engine and airframe manufacturers.

OPERATIONS: This new, modern one-floor plant is a self-contained division of United Aircraft Products, Inc. with machine shops and the most modern equipment for all types of welding, brazing and soldering operations. There are complete facilities for mechanical, fluorescent-penetrant, shadow-graphic and radiographic inspection; resident Air Force Inspectors; motor transport, rail-spur and air freight shipping of completed components.

EXPANDING BUSINESS: This new plant, with its 16 acres of ground and 90-thousand square feet of floor space, was acquired to furnish space for the completion of new and expanding contracts for sheet metal assemblies for the defense industries. These assemblies include customer-specified fabrication as well as proprietory components and systems.

MORE EFFICIENCY: By acquiring this new plant we are able to concentrate the various types of UAP activities within three major divisions in the interest of increased in-plant efficiency and the faster delivery of customer's assemblies from both plants.

DAYTON, OHIO: The Dayton facility, home of United Aircraft Products, Inc., since 1929, will continue the production of aircraft quality heat exchangers of all types, sheet metal assemblies and mechanical components for the control of temperatures and fluid flows. Engineering, research and prototype development, sales and executive offices also will remain in Dayton.

QUALITY: We are happy to offer this new facility to the defense industries. The same high standards for the production of quality components will be maintained in the Forest facility that has always characterized aircraft products made by United Aircraft Products, Inc.

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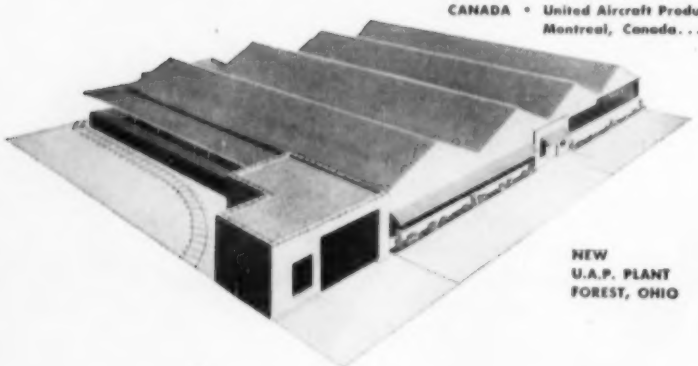

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the changes which should be made in naval doctrine, roles, missions, tactics, etc. in the light of modern technology.

Naval Research Laboratory

Naval Research Laboratory is one of the largest federal research and development facilities. Its program covers practically all of the areas of the physical sciences that have a naval interest.

NRL pursues programs of basic and applied research and also development in sound, chemistry, electricity, metallurgy, nucleonics, radiation, optics, mechanics, radio, radar communications, and weapons and supporting systems.

NRL was established in 1923 under the influence of Thomas A. Edison, in Washington, D. C. Today is represents a capital investment of more than $40 million, is spread through 84 buildings, and employs more than 3,000 men and women.

Auxiliary facilities are maintained around the Chesapeake Bay and in the Panama Canal Zone. Work in the Canal Zone primarily concerns tropical deterioration and exposure. That in the Chesapeake Bay area deals with fire control, tracking radar, and optics.

Great Electronics Effort

Specific programs are extremely varied and many have made significant contributions to the country's defense and general welfare. Radar development, which began in 1922, is perhaps the most important. Today, electronics accounts for about half of the work at the laboratory. Effort is made to improve components and basic theory as well as systems.

A related project at NRL is in radio astronomy which is concerned with the study of the strength, direction, and variation on radio-frequency emission from the sun, moon, and stars. NRL has been working in this field since 1946 and currently has the most modern and powerful equipment available in a 600-in. radio telescope. This NRL program is adding substantially to our knowledge of space.

Rocket Work

The rocket program at NRL has been extensive for the last 10 years. This program has been primarily for the purpose of upper atmospheric research. German V-2, Deacon, Aerobee and Aerobee-HI and Viking rockets are among the vehicles used for this research.

The most advanced portion of the program is Project Vanguard, which will place the first man-made satellite in orbit about the earth. NRL has been given technical responsibility for this project. This encompasses building, launching and tracking the satellite during its flight.

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Ford Motor Company established Aeronutronic Systems, Inc. as a Subsidiary to design, develop and manufacture weapons systems, subsystems and components for the military and related systems for commercial application.

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Data Links

COMPUTERS
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- unique solderless taper pin technique for permanent wiring to contacts.

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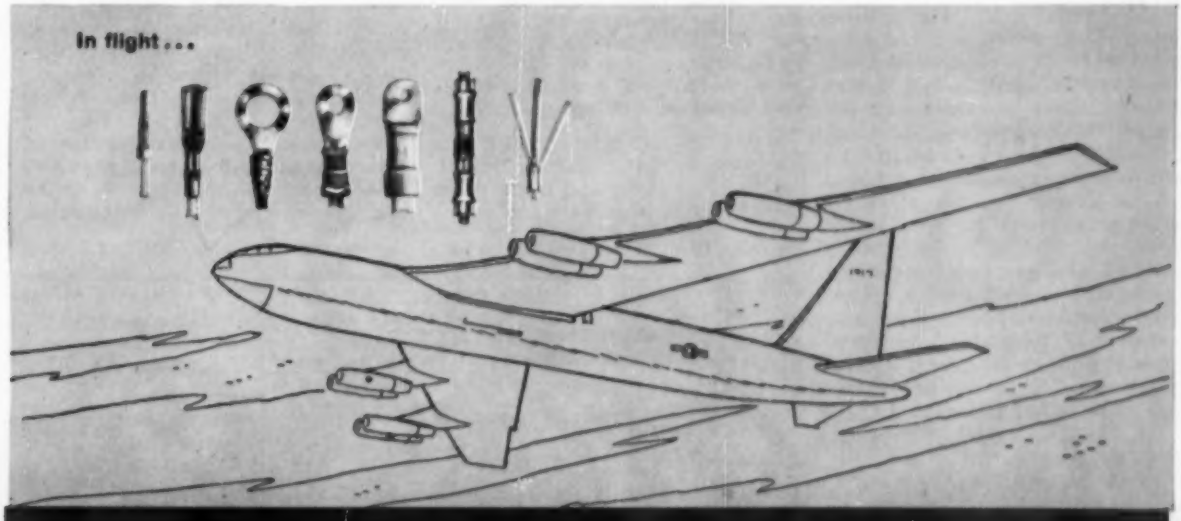
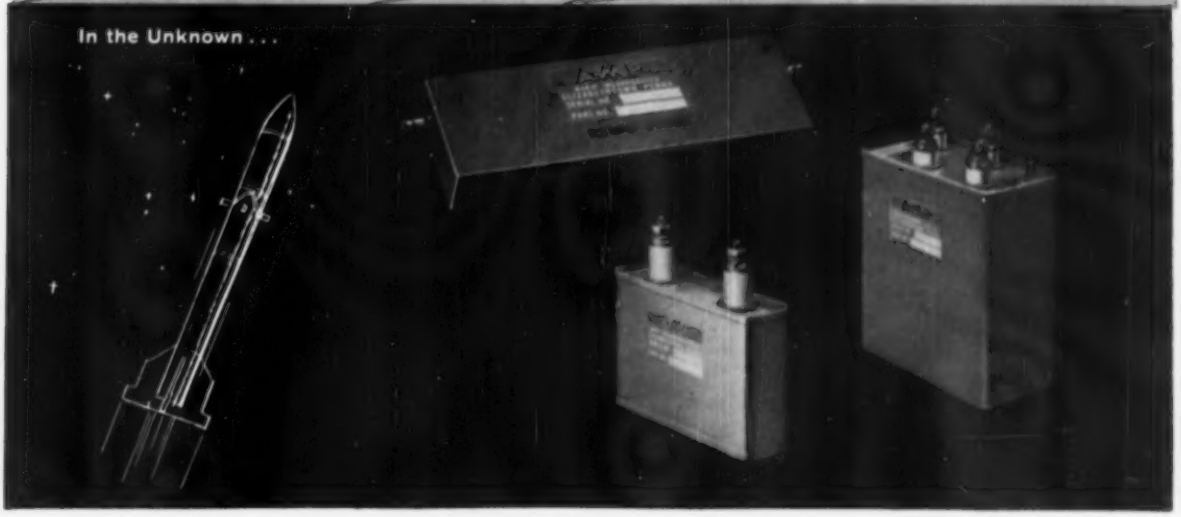




• NAVY

Air Test Center Speeds Navy's Missiles

By Irving Stone

Pt. Mugu, Calif.—Naval Air Missile Test Center speeds introduction of guided missiles into fleet use by performing a primary role in testing and evaluating the missiles themselves and their related components.

NAMTC's extensive complex of ground facilities, laboratories and sea range is brought into the picture early—when Navy's Bureau of Aeronautics first contemplates requesting bids for a new missile to meet a new requirement.

At this point, NAMTC serves as consultant to BuAer and assists in establishing specifications. NAMTC considers this service important, because it brings the center in on the ground floor and facilitates its later task of evaluating the actual hardware.

BuAer initially screens bids for contractors' eligibility and for other details. NAMTC then reviews the selected bids in a consulting capacity, advising BuAer on the relative merits of the various missile proposals. NAMTC is only one agency BuAer might consult.

NAMTC Monitors Development

After contract award, BuAer usually assigns NAMTC the responsibility for technical monitoring or control of the contractor's developmental work. In this way NAMTC figuratively looks over the shoulder of the contractor as the missile progresses through design, fabrication, and flight development. The latter is conducted at NAMTC or at facilities contracted for by the center.

NAMTC usually supplies support aircraft (launching, photographic, chase and instrumentation planes) and pilots to conduct a contractor's requested flight development. Sometimes the contractor supplies his own pilots to fly aircraft bailed to him by BuAer. In this case, an NAMTC observer pilot participates in the program.

For a contractor's flight development work—which precedes demonstration of the missile and Navy prototype and technical evaluation tests—NAMTC also supplies office and shop facilities, use of the instrumented sea range, data reduction facilities and other necessary services.

Regulus and Sparrow Tested

Under this general arrangement, flight development has been done on such missiles as the Chance Vought surface-to-surface Regulus I and Sperry air-to-air Sparrow I. Even though it is assigned to operation with the fleet, Regulus I still is undergoing product improvement here. This continued development testing is important for incorporating improvements into the production article.

Other missiles in various stages of development and test under NAMTC cognizance include the Regulus II and air-to-air and air-to-surface missiles.

Because BuAer also has responsibility for development and test of target drones, NAMTC's participation in this field is similar to that with missiles.

Ryan Firebee (KDA-1) was evaluated and tested here for Navy use and is now operational with the fleet. Product improvement, development and evaluation on the basic KDA still are in progress at NAMTC.

Other targets in various stages of development and test at NAMTC include the Beechcraft piston-powered KDB, the Temco rocket-powered XKDT-1 and the Radioplane rocket-powered XKD4R-1.

Two Types of Testing

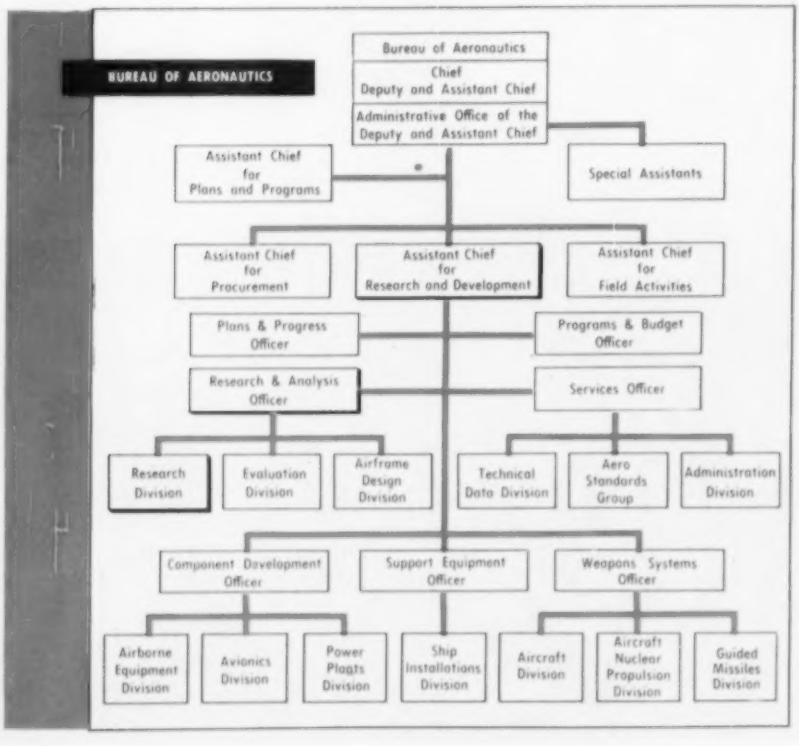
Following contractor's missile or drone demonstration, which is in effect, the hand-over of the unit to the Navy, NAMTC takes over the entire testing and evaluation program. It conducts two types of tests:

• **Prototype evaluation.** This is an accelerated simulated fleet environment test, generally spread over a 60-day period. A surface-to-surface missile such as Regulus would be tested in conjunction with auxiliary equipment—launcher, guidance, check-out devices, etc. For an air-to-air missile such as Sparrow, the prototype fleet aircraft—including its fire control system, missile pylons, etc.—would be involved.

Extremes of the tactical operational envelope are checked for feasibility in this accelerated test. This involves factors such as maximum and minimum altitude, speed, deflection angle, and range. Decision to enter large scale production frequently is based on results of this accelerated test.

• **Navy technical evaluation.** Usually conducted after the accelerated tests, technical evaluation is designed to determine missile system capability. This involves both flight and laboratory trials, including exhaustive simulator studies, and may take approximately a year.

Results of the overall evaluation should determine the entire operational envelope and environmental limits of the missile system. This information



To Fleet Use

would be fed to the fleet for its use in refining missile operational doctrine.

Captive Flights

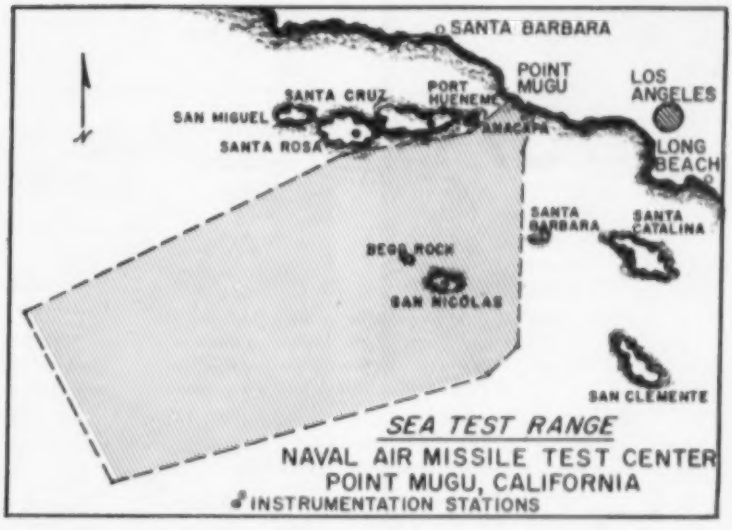
Not all flight testing under the technical evaluation or the contractor's development testing involves missile launching. In the case of Regulus, a TV-2KD jet has been fitted with the airborne components of the missile system to test maneuvers and overall guidance system functioning. A human pilot relinquishes control of the plane and serves only as a monitor. This form of missile guidance simulation minimizes loss of expensive missiles and test time, since one test plane flight can simulate several missile runs.

Captive-missile or drone flying also is done. The missile is mounted on the pylon of the carrier plane, but not released.

While the captive-missile is operated, instrumentation measures forces, error signals in the guidance system, missile response, and internal environments. With a high-speed carrier plane missile design speed may be met or extrapolated.

Countermeasures Studies

NAMTC, like other missile evaluation activities, determines missile susceptibility to countermeasures. If susceptibility is discovered, the contractor is required to design a counter-countermeasure. This, in effect, is refining the system to render it immune to the countermeasure.



NAMTC now is refitting a Convair R4Y as a flying countermeasures laboratory. Douglas F3D Skyknights and patrol aircraft already have been used for this purpose.

Inertial Guidance Laboratory

Because it would be impractical and uneconomical to obtain entirely from flight tests all the information needed to evaluate a missile's operation and determine its performance characteristics, NAMTC makes extensive use of ground test facilities to obtain a large percentage of the data required.

Some of the key facilities used or projected for use in NAMTC laboratory evaluation are:

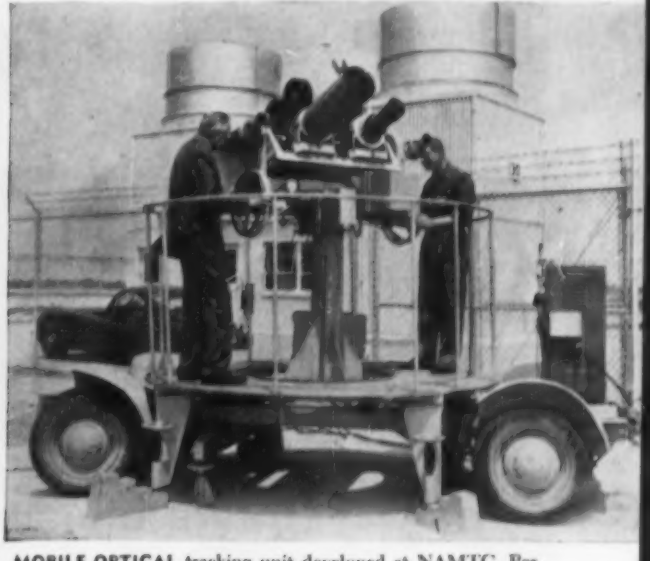
• **Inertial guidance laboratory.** Now in the planning stage, this facility will be used for evaluation of inertial guidance systems projected for long-range missiles. It probably will be in operation within two years.

• **Bendix three-axis flight simulator** and associated computer. This equipment can be used for dynamic testing of autopilots and other guidance system components.

Unit under test can be operated in any three planes simultaneously, simulating dynamic conditions which can exist during missile flight.

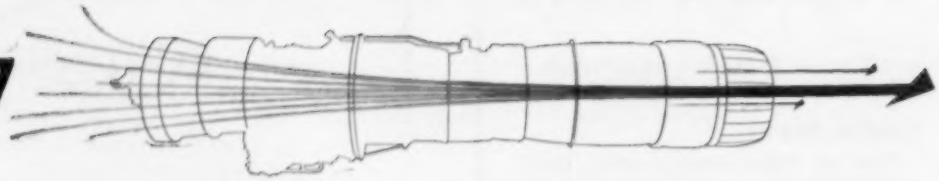
Output of the tested component can be fed into the computer, whose output is fed back to the table, creating a closed-loop system which simulates the entire missile system. This equipment is part of the functional simulation laboratory, which uses non-destructive procedures to generate, at a relatively low cost, information pertaining to

NEW BENDIX three-axis simulator table and associated computer perform dynamic missile, aircraft component tests in closed-loop system.



MOBILE OPTICAL tracking unit developed at NAMTC. Permanent theodolite installations can be seen in background.

J57



The J57 is a big bruiser!

This turbojet engine weighs more than 5,000 pounds, develops more than 15,000 pounds of thrust, has thousands of parts—one of the smallest of which, a fuel nozzle seal, you see here.

But what do these figures really say about the J57 we build? Do they say it was designed by Pratt & Whitney, a division of United Aircraft Company?

. . . that it takes complete cooperation among the designer, Air Force, and manufacturer to make certain every engine meets rigid performance standards.

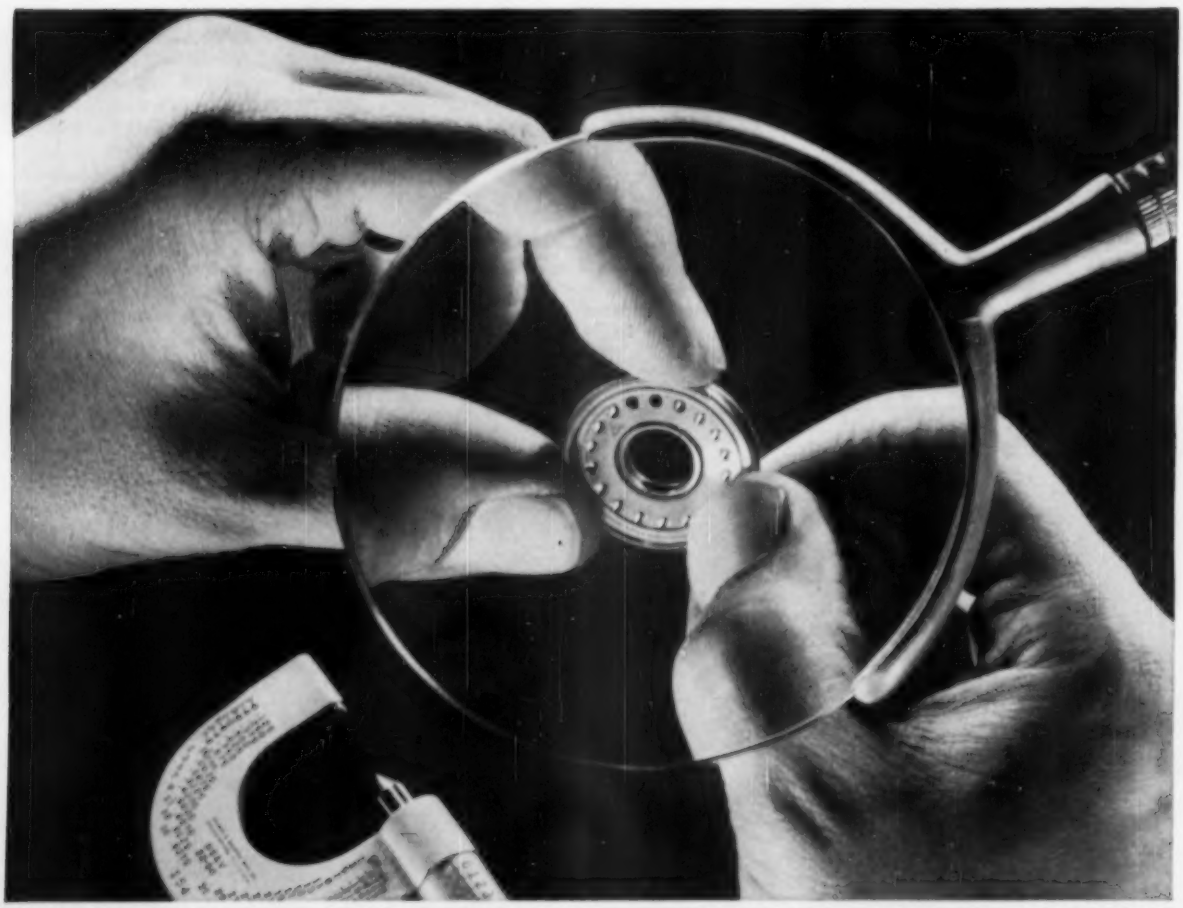
. . . that the J57 is used in some of the latest Air Force equipment: "century series" fighter models, B-52 intercontinental heavy bomber, and KC-135 tanker-transport.

. . . that it takes a vast network of parts suppliers reaching into 27 states to feed us the components we need to meet our schedules.

. . . that it takes teamwork *on every level* to establish and maintain quality volume production.

You can see cold statistics don't tell the full story. Unintentionally they miss this vital point: behind every completed engine lies a tremendous amount of cooperation and skill.

We believe the J57 jet engine is proof we've developed a high degree of both.



AIRCRAFT ENGINE DIVISION • FORD MOTOR COMPANY

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RADIOPLANE XKD4R-1 rocket-powered target drone positioned on pylon under F3D Skyknight wing for captive drone flight tests.

dynamic behavior of missile system components.

• **Catapult-type launching simulator.** This is used to subject missiles and components to approximately the same acceleration experienced in normal pylon launching. The procedure saves the missile and its components, and direct wire telemetry can be used for extensive instrumentation.

• **Restrained-firing facilities.** These may be used to test ability of a missile to withstand the environment produced by rocket motor burning. During the run, the missile is suspended and restrained by nylon ropes in conjunction with an air buffer. Here again, primary advantages are elimination of missile expenditure, and use of direct wire telemetry.

• **Environmental laboratory.** Facilities are used to determine effects of shock, vibration, acceleration, temperature and humidity on guided missiles and their components. One piece of equipment in this laboratory is a 15-ft. diameter centrifuge capable of imposing 200Gs on a 35-lb. component. With this load, the arm can be brought to full speed in 30 sec. One use is to simulate steady-state acceleration effects of a missile's boost stage on missile components.

• **Cassegraian (optical) infrared collector** and monochrometer. Now being used here for infrared studies, this van-mounted mobile equipment—designed and built at NAMTC—was used earlier atop Pike's Peak for a 30-day study of infrared spectral energy from sky and military target radiation, under all weather conditions. This was done to fill a gap in the knowledge of infrared sources and their detection.

• **Continuous flow wind tunnel.** Operated by University of Southern California personnel, this facility is used for research and development testing in the field of aerodynamics.

NAMTC's laboratories also contain the usual complement of shake tables, cold chambers, altitude chambers, humidity rooms, and electronic test equipment.

Instrumented Sea Range

For use in all missile and drone flight testing, including captive-missile checks, NAMTC maintains a completely instrumented range about 70 mi. wide and extending 150 mi. to sea from Pt. Mugu.

There are two main instrument locations in the sea range—one at Pt. Mugu proper, the other on San Nicolas Island, approximately 63 mi. offshore. Each site has equipment for measuring missile and aircraft (carrier or target) flight paths with radar or theodolite. Internal

Bureau of Aeronautics—R & D Funds

(New Obligational Authority)

	FY 1956	FY 1957	FY 1958
Aircraft and Related Procurement	$119,812,675	$122,755,800	$111,534,000
Guided Missiles and Related Procurement	34,347,857	32,420,000	36,244,000
Totals	$154,160,532	$155,175,800	$147,778,000

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New Bendix 20-Channel Glide Slope Receiver for Airline and Business Aircraft Features Big Performance in a Little Package

Here's the latest addition to the Bendix* line of ILS Approach Equipment. We call it the GSA-8A Glide Slope Receiver. You'll call it just about the most dependable instrument of its kind. And here's why:

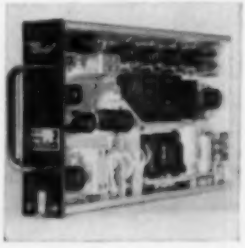
The GSA-8A is all new from circuitry to case. Not just a modification or repackaging of old designs. The result is a tremendously higher degree of course stability, and more accurate, reliable flag alarm information. Weight has been reduced considerably. The receiver weighs 7¼ lbs. with AC power supply . . . 7 lbs. with *transistorized* DC power supply.

The complete unit, including either power supply, is housed in a short ¼ ATR case. The chassis is mounted vertically. Tubes and adjustments are on one side, circuit components and wiring on the other. When the case is removed both *wiring* and *tubes* are visible, and access to each is easy for routine maintenance.

For further information write Bendix Radio Division, Aviation Electronic Products, Baltimore 4, Maryland. Or on the West Coast—10500 Magnolia Blvd., N. Hollywood, Calif.; Export—Bendix International Division, 205 E. 42nd Street, New York 17, N.Y.; Canada — Computing Devices of Canada Limited, P.O. Box 508, Ottawa, Ont.

*REG. U.S. PAT. OFF.

***ENGINEERS:** Because of our vast expansion program, several career opportunities are now available in the design and development of commercial aviation electronic products. We invite your inquiry.*



GSA-8A Glide Slope Receiver

Bendix Radio Division

Bendix AVIATION CORPORATION

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LANDING pitch station controls manned drone with Regulus missile guidance.

conditions in the missile or target drone can be obtained through telemetering.

For air-to-air missile tests where miss-distance information is critical, optical or electronic instrumentation is included in the target drone for accurate measurement. Miss-distance may be within lethal range for a missile that normally would be equipped with an influence fuse to detonate the missile within a specific separation distance from the target.

Extensive photographic coverage of missile launchings, flights and recovery also may be obtained. In testing an air-to-air-missile, the launch aircraft is fitted with a high-speed telephoto camera pod and is teamed with a similarly equipped photographic plane. From this film coverage, separation of missile from launcher, reaction to wing positions, and data on material failure can be obtained. By using triangulation and frame matching techniques, a continuous plot of space position also may be obtained.

Extensive radar installations are located at NAMTC's flight test control building at Laguna Peak, near the center; on San Nicolas Island, and on leased land at Santa Cruz Island. Radar video is relayed by microwave directly to flight test control point, allowing observation of the entire sea range for safety and control purposes. In addition, aircraft are used to search the range and some are equipped with loudspeakers to contact vessels within the range area.

Falcon, Talos and Terrier

NAMTC's range and facilities also are used by Air Force, Navy and Army. Because of the relative closeness of Hughes Aircraft to NAMTC, Air Force requested time on the range for the Hughes-developed air-to-air Falcon. NAMTC targets also were used.

Navy Bureau of Ordnance's surface-to-air Terrier missile frequently has been fired in realistic sea trials on the NAMTC range by the converted seaplane tender Norton Sound.

BuOrd's surface-to-air Talos also was evaluated here in sea-firings by the Norton Sound.

For practice firings of the Regulus I from shipboard or Sparrow I from carrier-based aircraft, the Pacific Fleet frequently uses the range because of its extensive instrumentation.

NAMTC operates a Technical Services Department, which maintains aircraft modification shops for installation of special instrumentation, missile control equipment, and missile launching pylons. It also operates machine shops, metal shops, and other facilities for preparation of electronic installations.

Approximately 2,000 civil service employees are engaged in NAMTC's program. About 390 of these are engineers and scientists.

The center has about 170 Naval officers, most of them pilots. Some have specialized training in electronics and related aeronautical engineering areas.

Contractor personnel on the base number about 1,500, including some 300 engineers and scientists.

Commander of NAMTC is Capt. D. G. Donaho, and Capt. V. H. Soucek is Director of Tests. The Naval Air Station, which maintains aircraft operated by the center and supplies overall support services, is under the command of Capt. J. C. Alderman. Missile Test Officer is Cmdr. M. A. Mason. ■

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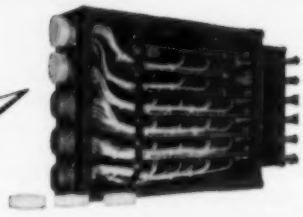

emergency fire control
this plunger-actuated, multipole assembly is installed at the flight engineer's console on the Douglas Globemaster. It feathers props, closes cowl and oil cooler doors, releases extinguishing fluid to one or more of six compartments, stops fuel and electrical service to fire area.

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of aircraft landing gear is assured by this complete nose gear harness assembly which includes Electro-Snap hermetics.

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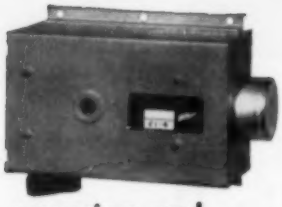
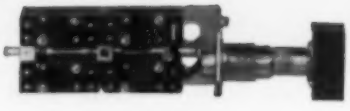
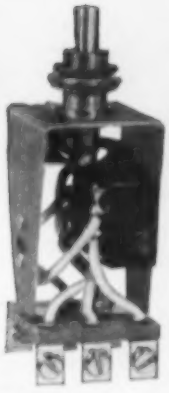


powering and de-powering
projectiles is dependably accomplished with this compact, hermetically-sealed assembly. Automatically actuated, it can be manually overriden. Design utilizes E-S rotary hermetic seal.

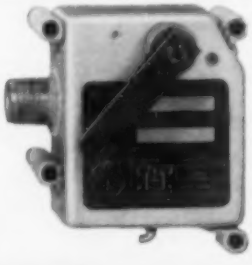


fire control switch
assures proper sequence during emergency fire conditions. Eliminates pilot error by controlling all functions when single handle is pulled.



rotary release switch
accurately controls release of fuel tanks and other objects from aircraft. Positive detent action assures finger-tip control and dependable performance.

rocket safety switch
assures tandem rockets will fire in proper sequence. Also indicates when rocket has been fired.



accurate control
of landing gear position is accomplished by this precision rotary hermetically sealed switch. Actuation occurs on either side of center within extremely close limits.

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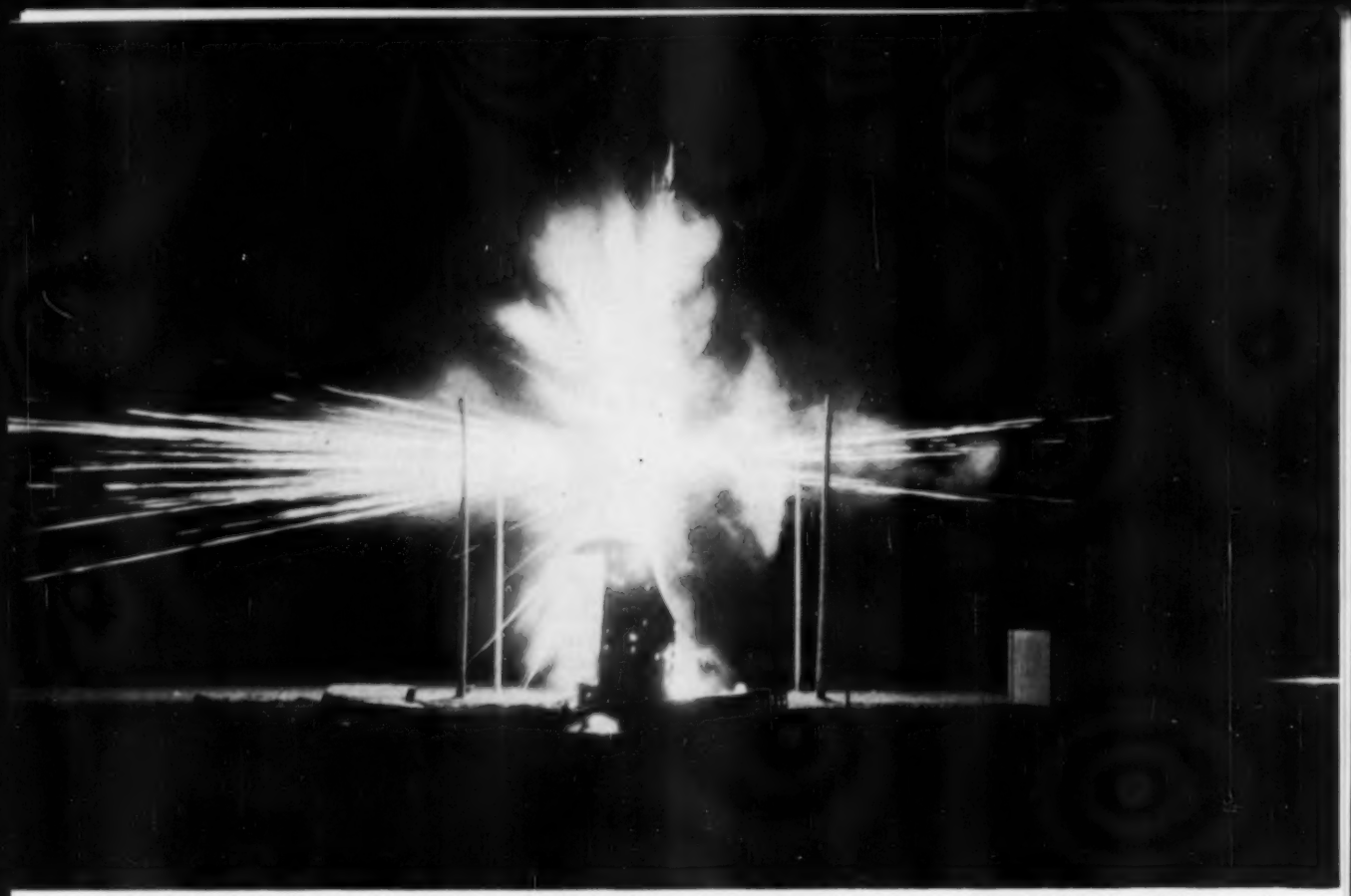


NIGHT WARHEAD BURST at Naval Ordnance Test Station is one of many types of tests conducted here in field of explosive research. Night firing allows perfect evaluation of explosion patterns for conventional missile warheads.

NOTS Converts Ideas Into Missiles

China Lake, Calif.—In a 1,000-sq. mi. corner of the Mojave Desert, a strong and efficient team of scientists, engineers, and military coordinators—backed by extensive modern facilities—start with an idea and end with an operational missile.

This technical team is the backbone of the Naval Ordnance Test Station, a Bureau of Ordnance activity and the Navy's largest ordnance research and development center.

Research, development and associated testing at NOTS is directed toward guided missiles and rockets in the air-to-air, air-to-surface, and surface-to-air categories, and to air-launched underwater missile configurations. This work embodies the systems concept and includes development of fire controls, launchers, and test equipment.

Sidewinder, Zuni

Among key ordnance items developed at NOTS under its own programs are:

- **Sidewinder air-to-air missile.** (AW Mar. 11, p. 26). Development included structure, aerodynamic configuration, infrared guidance, rocket motor, pilot presentation, aircraft-missile umbilical connection, launcher and test devices. Sidewinder was developed at NOTS under BuOrd cognizance. Some associated items, such as the launcher and the envelope computer, were developed under Bureau of Aeronautics cognizance.
- **Zuni, 5-in. air-to-surface rocket,** developed as replacement for high velocity aircraft rocket.
- **FFAR 2.75 air-to-air rocket,** used by both Navy and Air Force.
- **Various anti-submarine ordnance items.**
- **Various air-launched torpedoes.**
- **Fire control systems** for airborne guns and rockets. These systems have been perfected for NOTS-developed weapons as well as for those developed by other service activities.

As a result of fleet requirements generated by Chief of Naval Operations, BuOrd may assign a specific project—for example a missile—to NOTS either directly, or after a preliminary design competition between NOTS and other BuOrd activities or civilian contractors.

After the project has been assigned to NOTS, the relevant technical department such as Rockets and Missiles (RMD), Aviation Ordnance (AOD), or Underwater Ordnance (UOD) is assigned primary cognizance.

Assuming that the project is an air-to-air missile, RMD will organize a team of highly trained personnel from the Weapons Planning Group and the Applied Research, Engineering, Explosives and Propellants and Test departments. This team will assist RMD in design studies which ultimately lead to development of a finished prototype.

While RMD coordinates work of these various activities, it retains direct control of the guidance components. It also establishes necessary contracts with civilian agencies to aid in overall development of guidance and any other components in the missile system.

The Weapons Planning Group provides system concepts and mathematical analysis from the standpoint of system performance against specified require-

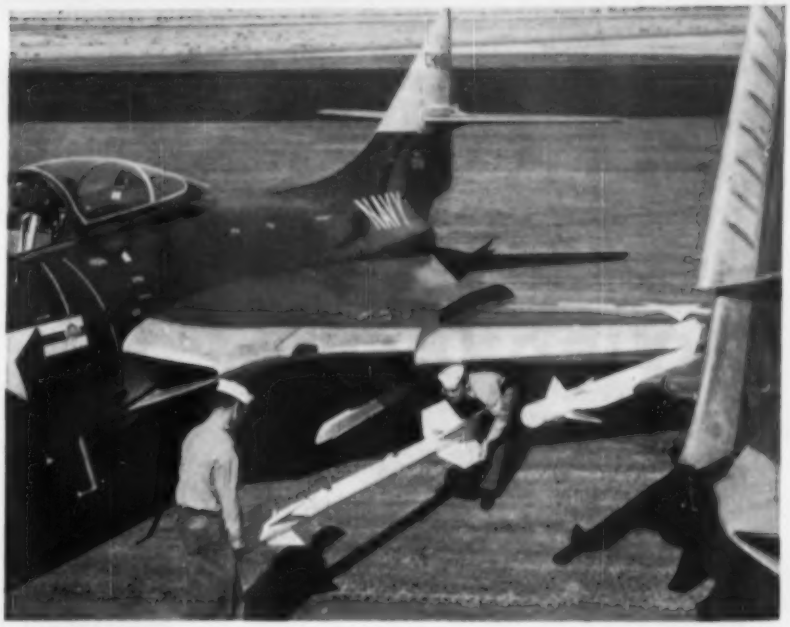
ments for the missile. Some of the details Weapons Planning projects are interrelationships between missile-aircraft compatibility and warhead size required to achieve desired lethality for specific targets.

The Research Department will contribute mathematical simulation for total dynamics of the missile and conduct aerodynamic studies, ballistic studies and chemical experiments which may provide advanced types of propellants to meet a new operational requirement.

Facilities available to the Research Department and Weapons Planning include an analog computer and latest models of digital computers. For aerodynamic and ballistic studies, Research also has available the Thompson Aeroballistics Laboratory, where scale model missile configurations are fired from a smooth-bore gun past a camera array to obtain data for aerodynamic and ballistic coefficients. This facility incorporates 22 pairs of cameras, spaced at 20-ft. intervals to record position and orientation of the missile as it is fired at speeds as high as Mach 5. Pictures are obtained at approximately 5-ft. flight intervals.

This free-flight firing range is instrumented for 460 ft. Location of missile model position can be determined to within .002 ft. Coefficients obtained include drag, normal force, pitching moment, magnus moment, magnus force, yaw damping moment, spin deceleration moment. Missile models up to 8-in. fin span have been free-flight fired in the laboratory.

For advanced propellant studies, the Research Department has complete facilities, including the latest equipment for nuclear magnetic resonance, X-Ray diffraction, and infrared spectroscopy, for gaining insight into detail structure of new liquid and solid propellants.



SIDEWINDER, Navy's highly reliable, relatively inexpensive air-to-air missile, is loaded aboard Grumman F9F. Missile was developed by civilian-military team at NOTS.

Rocket Exhaust Studies

Vapor phase chromatography equipment is used in conjunction with mass spectrographs to determine rocket motor exhaust gas composition and its relationship to burning efficiency and weapon system compatibility.

Supporting data which may require wind tunnel studies are obtained from outside facilities.

Engineering Department gets into the team action as early as possible to evaluate design details in order to insure producibility as development progresses. One key job of engineering is to attain maximum economy in production without compromising performance aims. Engineering's supervision in this role encompasses mechanical and electrical features of the missiles, materials, and overall structure. It not only evaluates designs on the basis of feasible production concepts. but also conducts tests on actual hardware that may have been produced in model shops or in Engineering's manufacturing division.

Engineering Department equipment includes vibration tables, strength of material testers, centrifuges and a high altitude chamber for simulating missile environmental conditions such as pressure, temperature, humidity and vibration, which are encountered in high-performance carrier-aircraft operation.

Engineering Department also has responsibilty for design and development of shipping containers and has facilities to determine, under dynamic conditions, ability of the container to withstand G-loading expected in transit.

CONVAIR TERRIER surface-to-air missile is fired from mobile ground launcher at Marine Corps station. Marines maintain one of NOTS' permanent Guided Missile Units.

High-Production Propellants

Explosives and Propellant Department develops propellant formulations and grain configuration for incorporation into the missile motor. This work involves plasticizing and extruding the propellant mass at NOTS' propellant pilot plant.

In this basic development, emphasis is placed on propellant mixes and extrusion techniques amenable with high-rate production processes. On occasion NOTS has developed equipment to permit propellant-package manufacture

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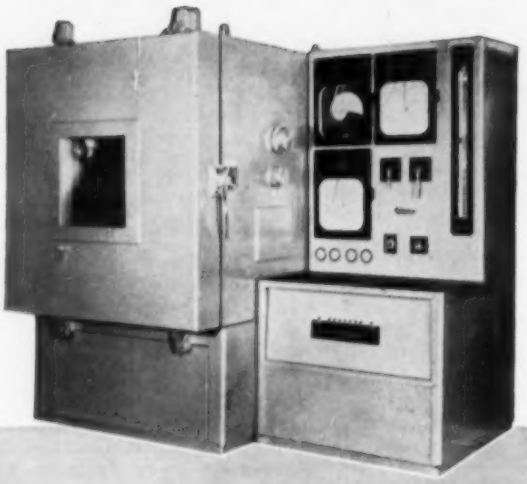

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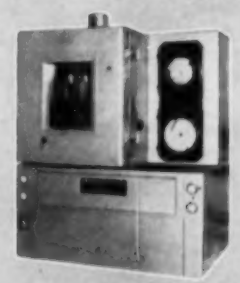

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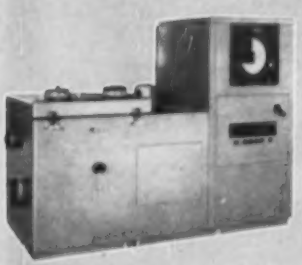

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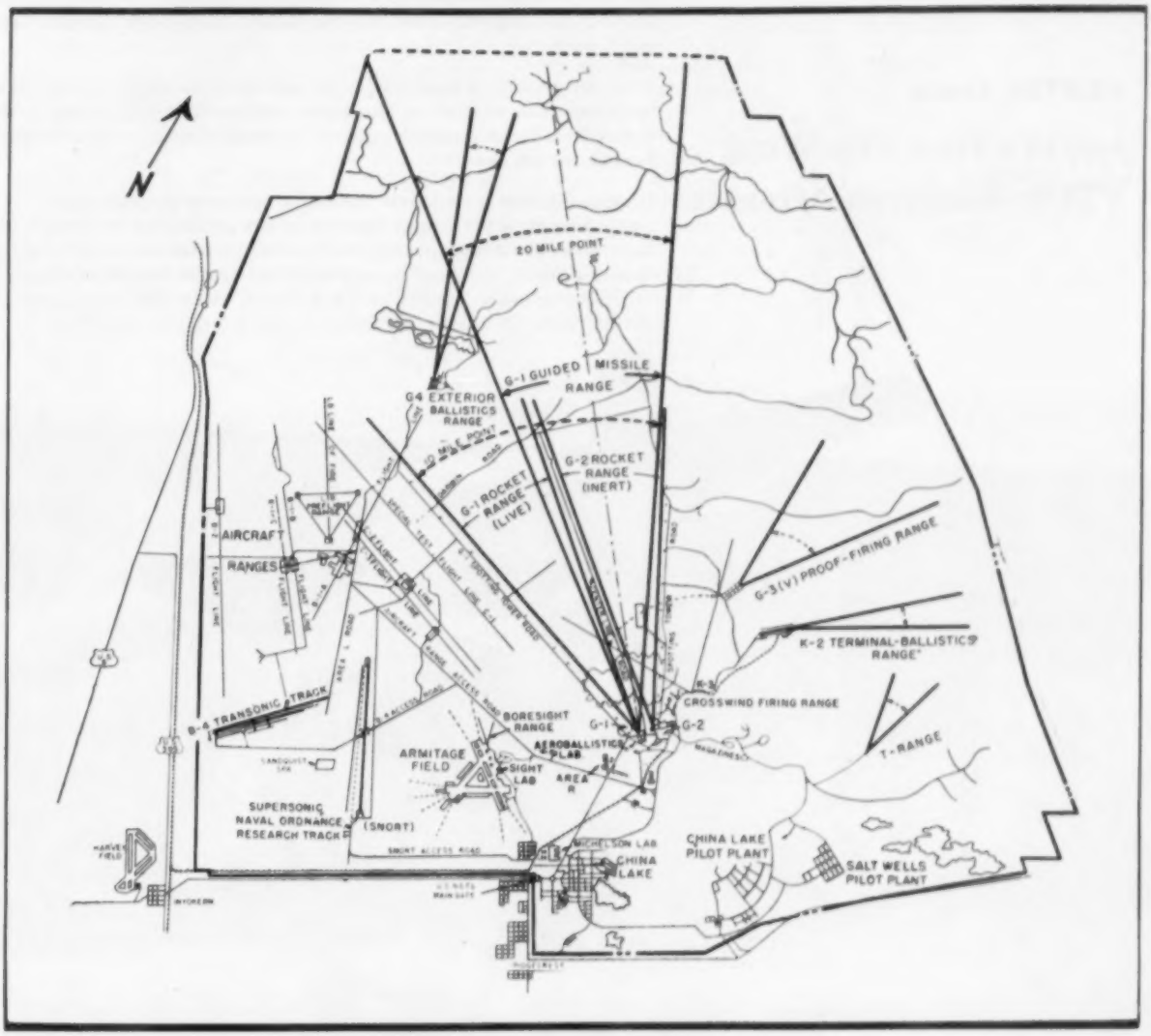

on a production basis at other activities.

Explosives and Propellants Department operates static test bays to determine thrust burning time, flame temperatures, wall pressures and related factors. There also is a lightly instrumented range for preliminary free-flight testing of the missile motor encased in a dummy missile configuration to study operational safety and handling. Rocket motor cases and dummy missiles are made by Engineering's manufacturing division.

Another key responsibility of Explosives and Propellants is warhead design—fragmentation type, shaped charge, or special configurations.

Components Tested

All these groups do their jobs under coordination of Rockets and Missiles Department until component assemblies become available for tests outside the laboratory. At this time, components are subjected to captive and free-flight testing on one of the Test Department's range facilities.

Preliminary tests of the guidance system would be made through captive runs on an aircraft and on a track sled. The aircraft tests would be made primarily to get data on ability of the system to acquire and track various types of targets. Sled runs would determine whether the guidance system is capable, under simulated dynamic conditions, of tracking the target and providing information that the control system must have for proper operation of the missile.

In other tests, the fuse-warhead combination is accelerated to normal flight velocity and released for free flight against actual or simulated targets. This determines proper function of safety and arming devices associated with the warhead.

It also determines that the fuse will cause detonation against various target conditions and that the warhead is lethal within the required limits.

Facilities available for component testing include the SNORT (Supersonic Naval Ordnance Research Track) complex. This consists of SNORT proper, a 4.1-mi. track capable of providing speeds up to 2,500 fps., with recovery of the test item; a 3-mi. section of track for use where destruction of the test item is anticipated; and a 3,000-ft. track for terminal ballistics studies.

Test Tracks, G-Range Used

Another complex, known as the G-range, is a highly instrumented area for component testing and full-scale missile free-flight proving, with launching from an aircraft. The complex is a pie-shaped section about 33 deg. wide and 37 mi. long. It is equipped with telemetering facilities and photometric devices such as Askania theodolites, Mitchell chronographs and Bowen trajectory cameras. There also is a ground

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The Model 76, soon to undergo flight tests, has been developed by Vertol for the Army Transportation Corps and the Office of Naval Research as part of the military's ceaseless quest for greater mobility and efficiency. From flight tests will come experience and knowledge applicable to the bright future of VTOL in military and commercial aviation.

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station for drone target control as well as voice vector information to place the missile's carrier-aircraft in proper firing position for desired test conditions. All records from instrumentation stations are tied together by central station timing.

In addition to the SNORT and G-range complexes, there are a 1,500-ft. track for terminal ballistic data; a special track for cross-wind firing of rockets from moving vehicles; a large-scale fuse-testing establishment; and a small-scale proof-firing facility for rockets with high explosive heads.

The various ranges cover an area of about 606,000 acres.

Full Missile Sled-Tested

After components are proved and incorporated into a complete weapon, tests are run on SNORT to precheck interactions between aircraft local flow conditions and launcher and missile under dynamic firing conditions.

An actual aircraft structure, such as a wing section with launcher, is used as a missile firing platform, traveling at the expected Mach number for the aircraft. Telemetering, track velocity measurement and long focal length tracking cameras are employed to record launch conditions precisely.

Following successful SNORT trials, the missile is tested on the G-range in firing from its actual carrier aircraft. Compatibility of the missile with the aircraft already has been demonstrated with a structural section in previous SNORT tests. This development testing continues with NOTS-built prototype missiles until the design has been firmed sufficiently to permit turning it over to a contractor for the first production model. Meanwhile, NOTS continues to incorporate improvements into the basic design.

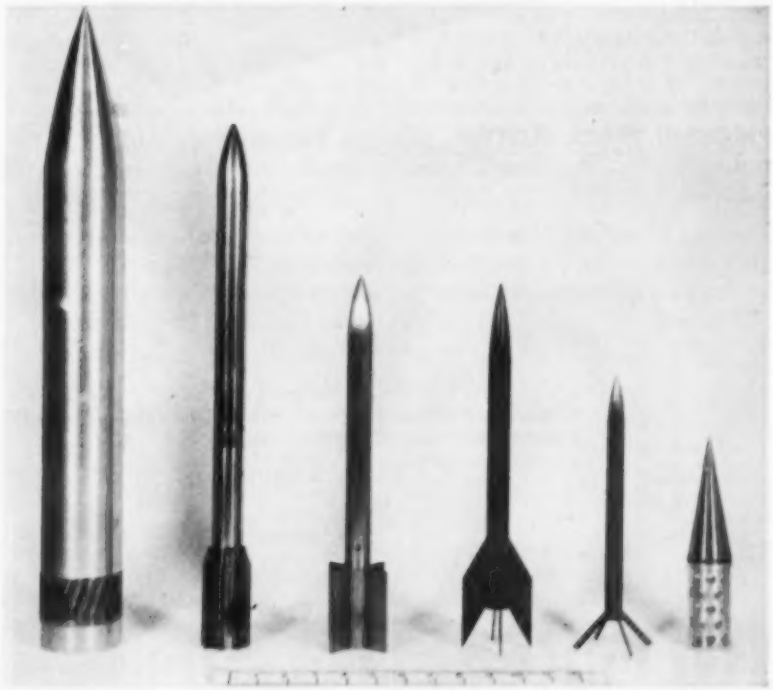
The first contractor-produced missiles to NOTS for final test and evaluation before the decision is made to release the weapon system to the fleet. This final check is conducted with a sufficient number of missiles to permit a high degree of confidence in reliability and performance.

Fleet aircraft, as well as advanced aircraft, are supplied for projects and for logistic support from a Naval Air Facility, integrated into the NOTS operation. Drone aircraft also are furnished. Integrated with this Naval Air Facility are any AF planes or drones which may be utilized in conjunction with NOTS developments.

Auxiliary Bases Aid NOTS

NOTS also has facilities at Pasadena, Morris Dam, Long Beach (sea test range) and San Clemente Island. Among other things conducted by these auxiliaries is development of air-launched torpedoes, which are tested in one of the phases on a variable-angle launcher at Morris Dam.

General pattern of design, development and test for the air-launched torpedo work is comparable to missile development at China Lake, except that



MISSILE MODELS tested at Naval Ordnance Test Station's Aeroballistics Laboratory.

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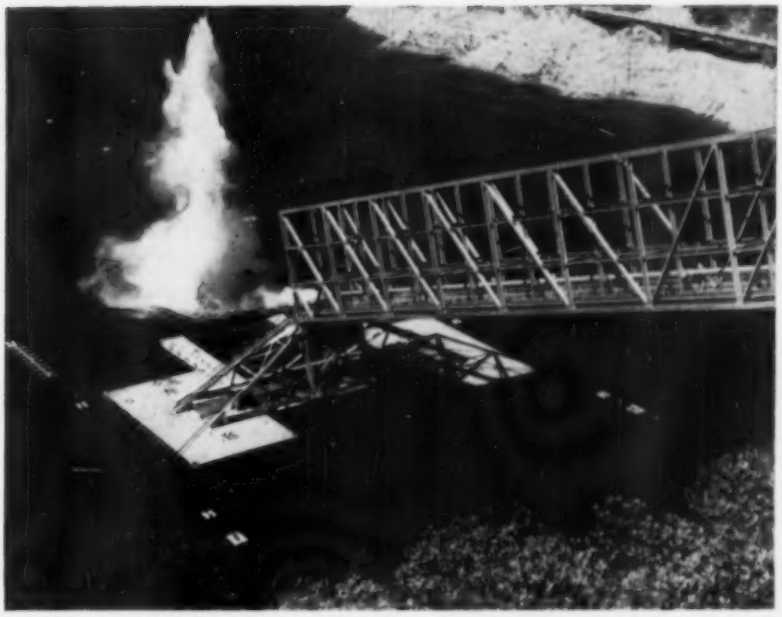


VARIABLE ANGLE launcher at Naval Ordnance Test Station's Morris Dam facility is used to simulate air launch of torpedoes developed by Underwater Ordnance Department.

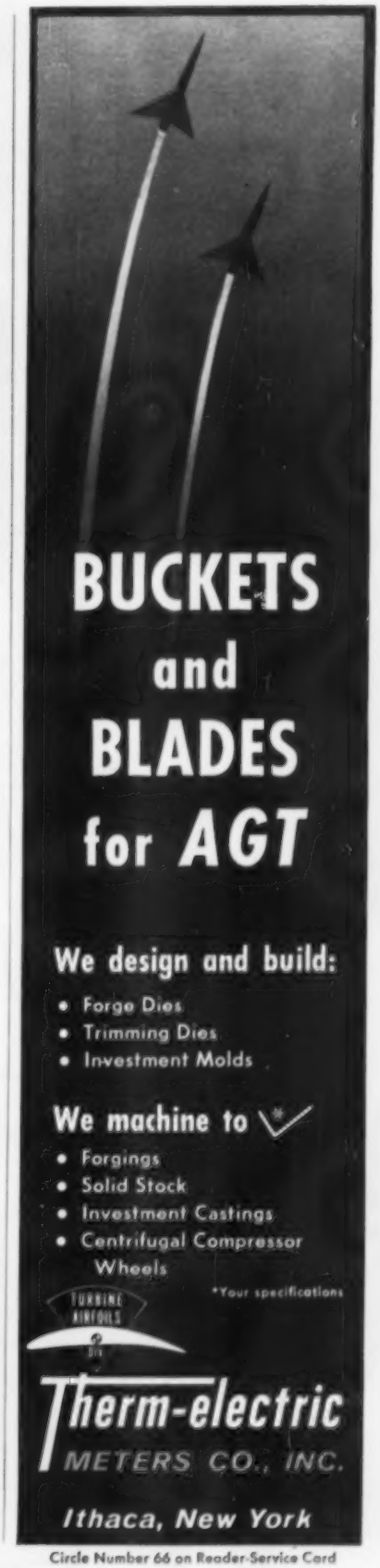
prime cognizance of the project rests with NOTS' Underwater Ordnance Department. Similarly, fire control system development at NOTS China Lake station would be under jurisdiction of Aviation Ordnance Department. AOD also may be given missile cognizance, depending on specific skills required for development of the missile involved.

For AOD fire control system development, a special test range is available for air-to-ground rocket or gun firing and high altitude bombing. An array of instruments accurately positions the point of bomb release from the aircraft and gives trajectory information to impact. Information on aircraft speed, altitude, and winds aloft also are obtained to permit determination of fire control system capability for delivering the bomb accurately.

Overall facilities at NOTS get maximum utilization, since they also are available to other services and to contractors. SNORT, for example, is being used for Air Force B-58 supersonic bomber escape system evaluation and to provide data on aerodynamic loading and flutter characteristics of advanced USAF and BuAer aircraft and designs.

Guidance components for intercontinental and intermediate range ballistic

DOWNRANGE view of Aeroballistics Laboratory shows 23 camera stations, shields for line light sources above. Scotchlite on ceiling is background for silhouette photos.



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**Avro Arrow is the official name of the still secret CF-105, now under advanced development in Canada.*

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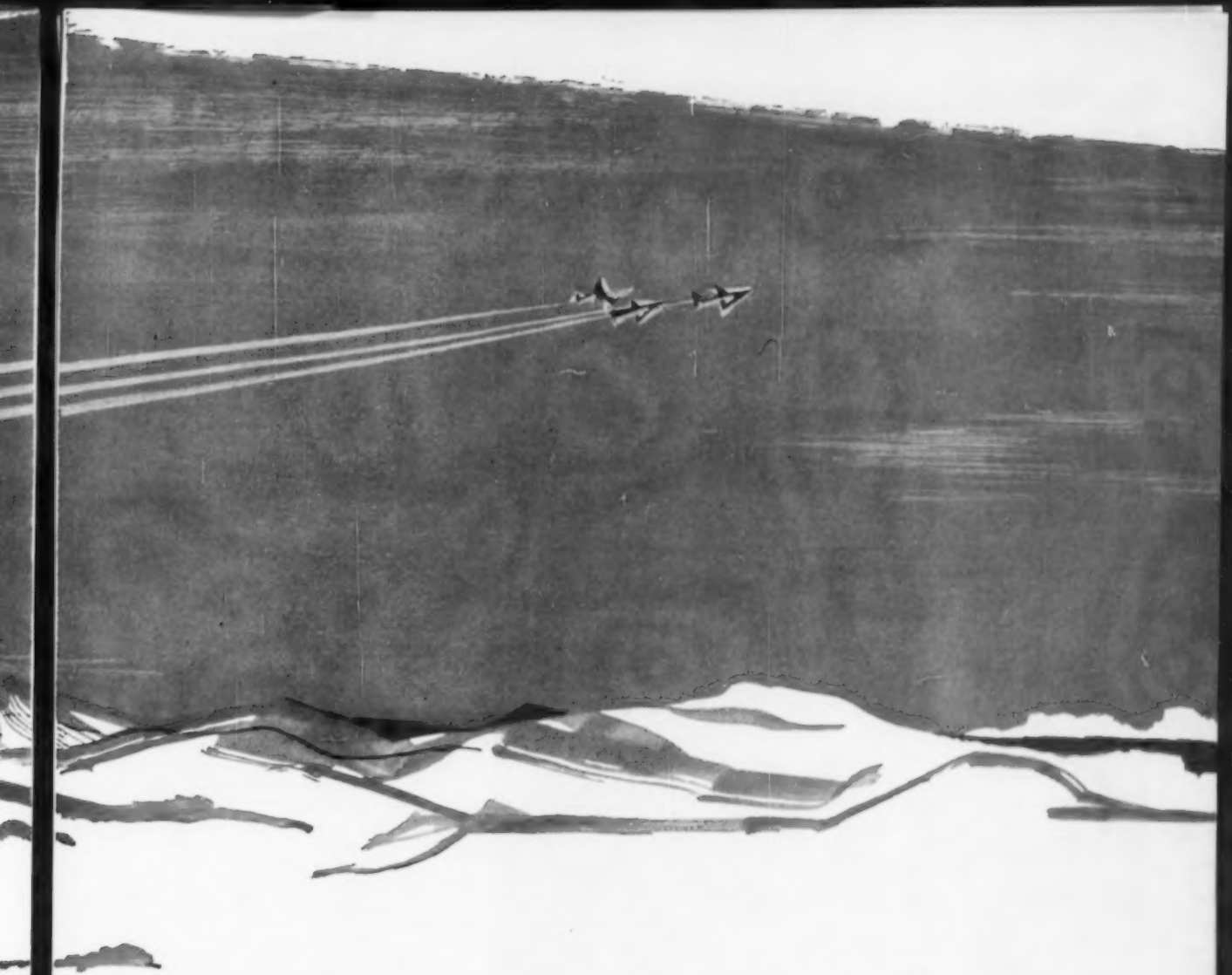

equipped Avro Arrow* will help protect the northern reaches

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Being built into this remarkable air defense weapon is a system of controls and instrumentation so complex that we can do little more than mention them here!

Perhaps the most revolutionary concept and certainly the most advanced control equipment ever to be installed in an aircraft of this type—is the new integrated electronic weapons, navigation and communications systems developed jointly by R.C.A. and Honeywell's Aeronautical Division.

Honeywell's contribution to this joint effort includes the electronic flight control equipment, instrumentation, air data computer, vertical reference instrument platform and fire control coupler. These will be integrated into the overall electronic system.

In addition, Honeywell has developed transistor fuel quantity measurement and management, dynamic damping, exhaust gas temperature indication and hydraulic servos and valves for the Avro Arrow.

Designing and engineering the control systems for the Avro Arrow, in co-operation with the RCAF, Avro Aircraft, and the governments of Canada and the United States, illustrates how today's modern aircraft and missile design makes use of the specialized skills and technical experience of Honeywell's Aeronautical Divisions in the United States and Canada.

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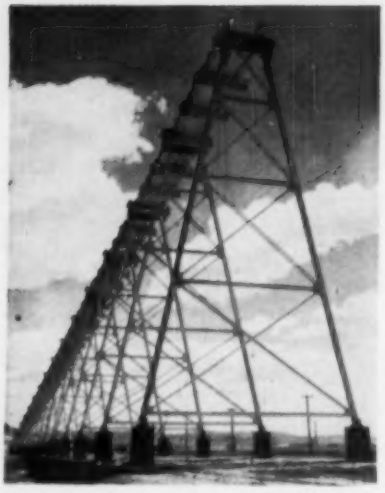


RAMP launcher permits simulated aircraft firing in tests of missile propulsion systems.

missiles are being checked on SNORT for G-loading and vibrational environment under contractor development programs.

Other activities at NOTS include test programs relating to countermeasures, rockets, missiles, warheads, fuses, guns, bomb drops, etc. NOTS makes available experienced personnel to design the test procedure and perform the test runs to obtain the data required.

Less than 20% of the station's effort is directed to evaluating other organizations products.

Total cost of facilities at NOTS is $230 million. Total funds for Fiscal 1957 are about $54 million. Approximately 82% of this was allocated to projects. This was an increase over Fiscal 1956, in which total funds were $48 million, with 79% allotted to projects.

Total amount of effort the station puts into development of a weapons system represents only about 3% of the cost of production of such a system.

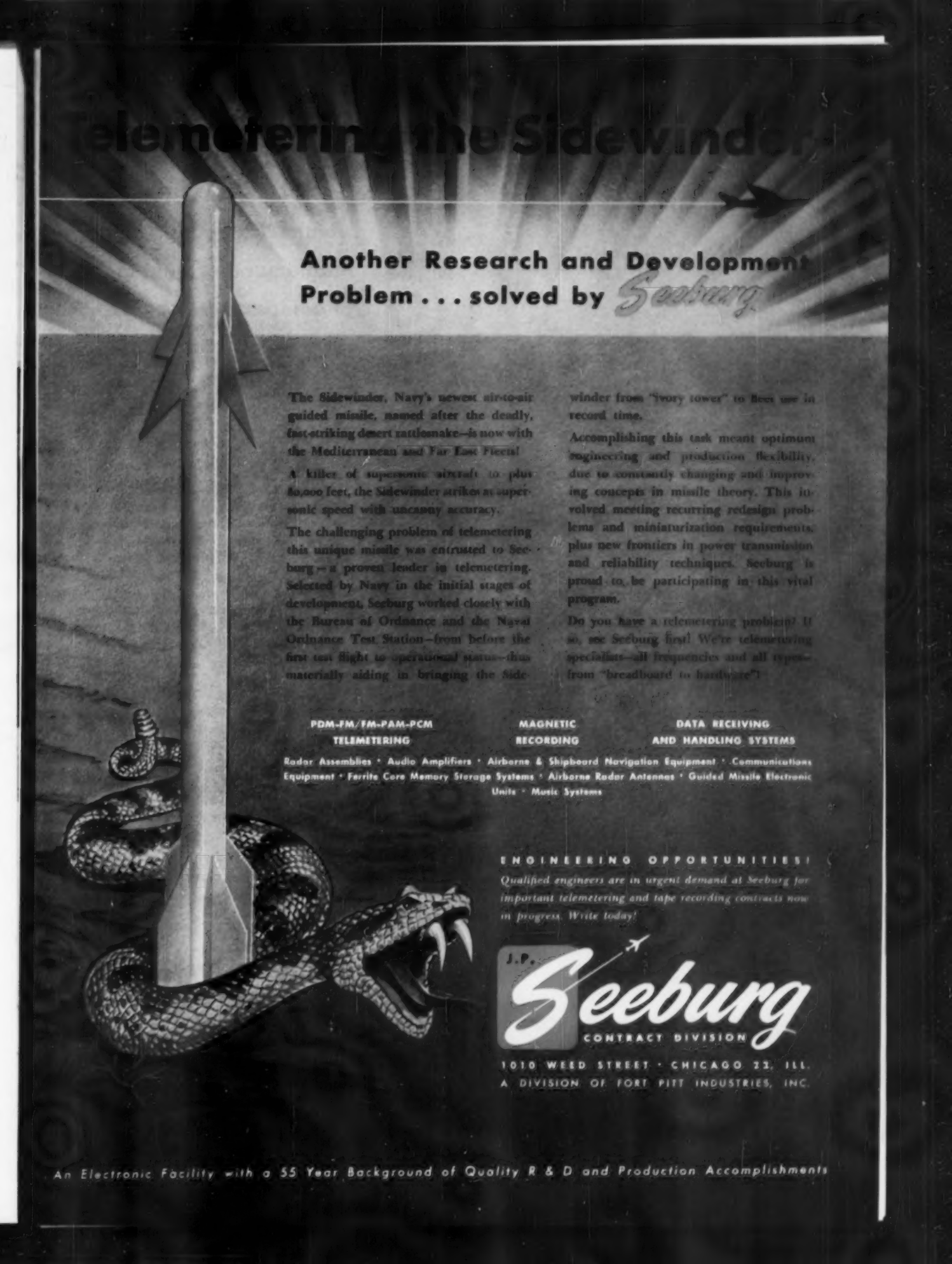
Despite its location in a desert area, NOTS at China Lake has been developed into an integrated military-civilian community. It now houses about 12,000 people within its gates.

Commander at NOTS is Capt. F. L. Ashworth, USN. Technical director is Dr. William B. McLean.

There are about 4,800 civilian employees, some 20% being engineers and scientists, including approximately 100 PhDs; and another 25% technicians.

There are about 1,400 military personnel at the station, including Navy Guided Missile Unit 25 for testing surface-to-air missiles; GMU6 for air-to-air missiles, and a Marine Corps GMU for surface-to-air missiles.

Navy is charged with management of the station and key liasion with the fleet. Civilian personnel, in the main, conduct the actual research, development and test work. ■



Another Research and Development Problem . . . solved by Seeburg

The Sidewinder, Navy's newest air-to-air guided missile, named after the deadly, fast-striking desert rattlesnake—is now with the Mediterranean and Far East Fleets!

A killer of supersonic aircraft to plus 80,000 feet, the Sidewinder strikes at supersonic speed with uncanny accuracy.

The challenging problem of telemetering this unique missile was entrusted to Seeburg—a proven leader in telemetering. Selected by Navy in the initial stages of development, Seeburg worked closely with the Bureau of Ordnance and the Naval Ordnance Test Station—from before the first test flight to operational status—thus materially aiding in bringing the Sidewinder from "ivory tower" to fleet use in record time.

Accomplishing this task meant optimum engineering and production flexibility, due to constantly changing and improving concepts in missile theory. This involved meeting recurring redesign problems and miniaturization requirements, plus new frontiers in power transmission and reliability techniques. Seeburg is proud to be participating in this vital program.

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Developed under the sponsorship of the U. S. Army and the U. S. Air Force, the T-53 has already been selected to power the Army's newest Utility 'Copter (Bell XH-40). Bell and Kaman have made their initial flights with Lycoming T-53 turbines. Even now the T-53 is being installed in boats, and stationary power plants are under consideration. Yet it is in the field of turbo-prop applications that the T-53 might very well offer its most exciting possibilities.

Ready to take to the air, the complete turbo-prop weighs only 460 lbs. and delivers 960 h.p. from a compact 47.6 length x 23-in. diameter. Using a variety of fuels including automotive and aviation types, gasoline and JP-4, it operates at a low 0.655 lbs. per e.s.h.p. per hr. consumption. Rugged design features and unprecedented ease of maintenance guarantee safe operation and long life.

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NATTS is World's Top Jet Test Facility

By George L. Christian

Trenton, N. J.—The Naval Air Turbine Test Station and its associated Aeronautical Turbine Laboratory are swinging into operation with intensive test programs on a multitude of new and old gas turbine engines.

Currently, only turbojet and turboprop engines are involved. Later test activities will expand to cover the whole gamut of airborne powerplants, including ramjets and pulsejets.

Tests now are being run to explore such questions as engine flame-out and re-light characteristics at various altitudes; compatability of new types of fuel with various jet engines, and overall high and low altitude performance of gas turbines.

When additional facilities now in the planning stage become available, fuel controls, pumps and hydraulic components and other accessories will be tested while in operation on an engine. This will give a complete picture of the functioning of a fully integrated engine/accessory package.

The $40 million Navy station, possibly the world's most powerful and complete jet engine test facility, was dedicated in November, 1955 (AW Oct. 17, 1955, p. 60). NATTS is under the technical direction of the Bureau of Aeronautics, and works closely with the Naval Air Development Center at Jonesville, Pa., and the Naval Air Material Center at Philadelphia. Commander is Capt. W. E. Kenna.

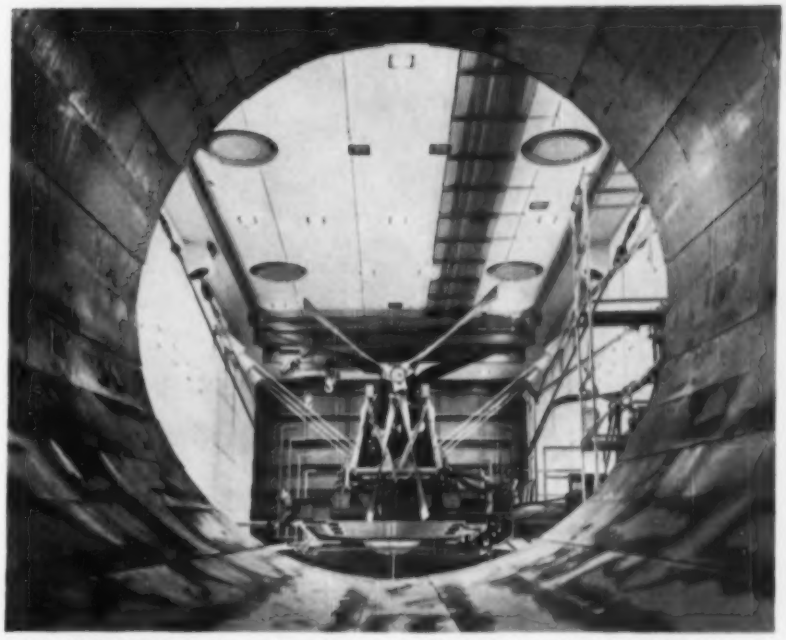
Initially, the Turbine Laboratory was beset with operating, organizational and budgetary problems. Such growing pains are to be expected in an activity using such enormous and complex machinery for which there is little operational precedent, Navy says.

A NATTS official pointed out that a reorganization was instituted recently to increase effectiveness of the station and of the laboratory staff. One result was to create additional positions on the laboratory staff. A vigorous recruiting program has been launched to fill them.

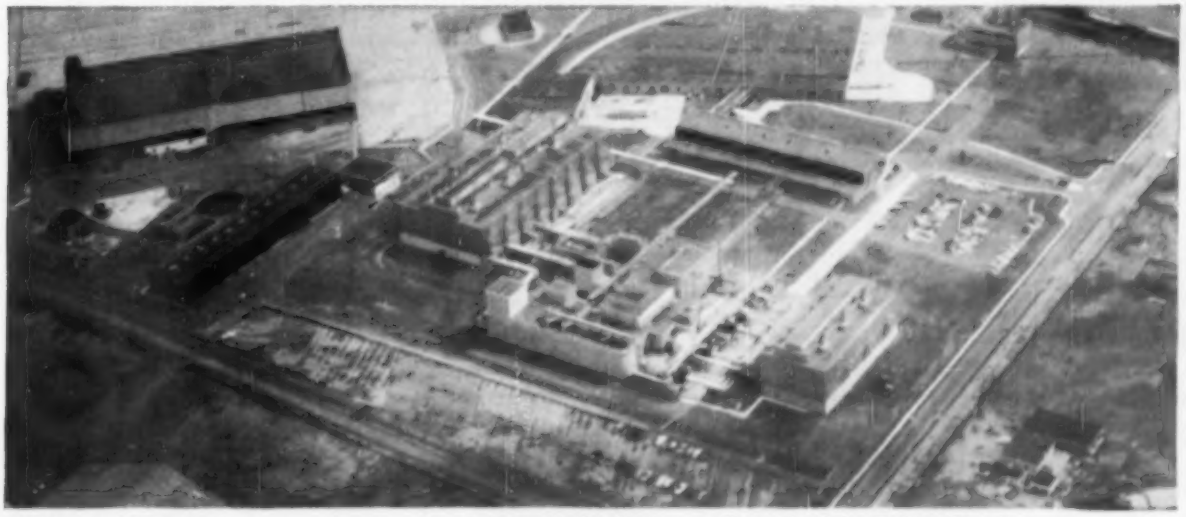
A spokesman for NATTS gave AVIATION WEEK this example of effective research recently accomplished by the Aeronautical Turbine Laboratory for Navy:

Last fall a problem vital to the fleet arose. A new first line fighter was planned for fleet deployment in operations where it would be required to burn a type of jet fuel never previously used with the engine.

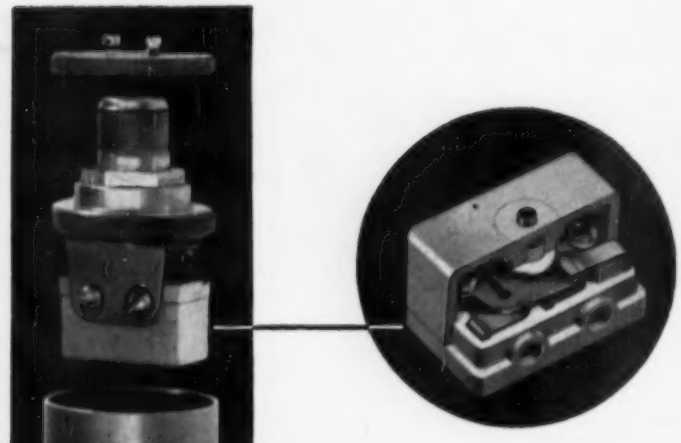
A high priority test program was conducted in a NATTS altitude test chamber to check compatability of fuel and engine. Special emphasis was placed



YT40 TURBOPROP engine undergoing test in cell which has adjustable orifice.



RAMJET, PULSEJET and engine components testing facilities will be added eventually to Naval Air Turbine Test Station.



New MELETRON
Pressure Actuated Switch
features
KLIXON
Precision Sine Switch

In designing its new Tier-Tube pressure actuated switch, Meletron Corporation, makers of over 500,000 aircraft pressure switches, turned to the Klixon Precision Sine Switch as a basic component.

Why?

Here's how George A. Starbird, President of Meletron, puts it:

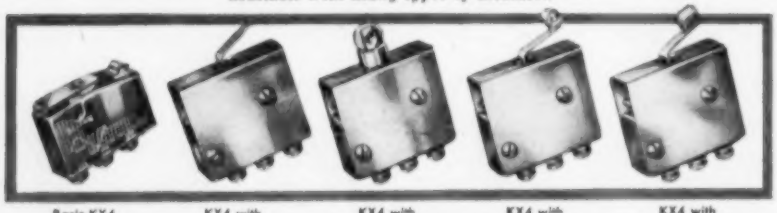
"We found that the Klixon Sine Switch is more resistant to vibration; has a more satisfactory current rating and a more uniform gap than any snap action switch that we have used in the past."

This J Series Klixon Sine Switch, like other models in the Klixon line, is a highly precise, sensitive snap switch for applications requiring extremely small movement differential with high shock and vibration resistance.

Movement differential as well as operating and release forces can be precisely adjusted and set to meet a wide variety of application requirements. Once calibrated, the Klixon Sine Switch precisely maintains its operating characteristics throughout its life.

For full details on Klixon Precision Switches, write now for catalog sheets PRSW 1, 2, 3, 4 and 5.

Another Klixon Precision Sine Switch is the Klixon KX4, available with many types of actuation —



Basic KX4 Sine Switch | KX4 with leaf actuator | KX4 with roller-leaf actuator | KX4 with roller-plunger actuator | KX4 with roller-leaf actuator

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Spencer Thermostat Division — 2806 Forest Street, Attleboro, Mass.

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on determining high altitude air starting characteristics of the new fuel. NATTS tests showed that the fuel had satisfactory high altitude relight characteristics. These investigations, complemented by flight test evaluation of the fuel, allowed Navy to make a sound decision to send the fighter to the fleet.

In the past nine months, NATTS has issued nine engineering reports covering such operational problems as flame-out and air start limitations and air start procedures on a variety of gas turbine engines.

Latest Engines Tested

Powerplants involved included the Westinghouse XJ54, Wright J65 and Allison J71. Test projects currently are being planned for the Pratt & Whitney J75, Wright J67, General Electric J79 and Allison T40.

Other projects conducted by the facility since it began operation two and a half years ago include:

• **Evaluation of engine high altitude** performance from sea level to high altitude. Purpose is to compare actual performance against guarantees and estimates made by the manufacturer in his engine specifications.

• **Investigation of installation effects** on engines. Distortions are imposed on air inlet flow to the test engine. This duplicates inlet patterns that might be experienced on the actual airplane to predict what effect they will have on engine performance. Other data also checked include cooling air requirements and other fuel, air and exhaust installation effects.

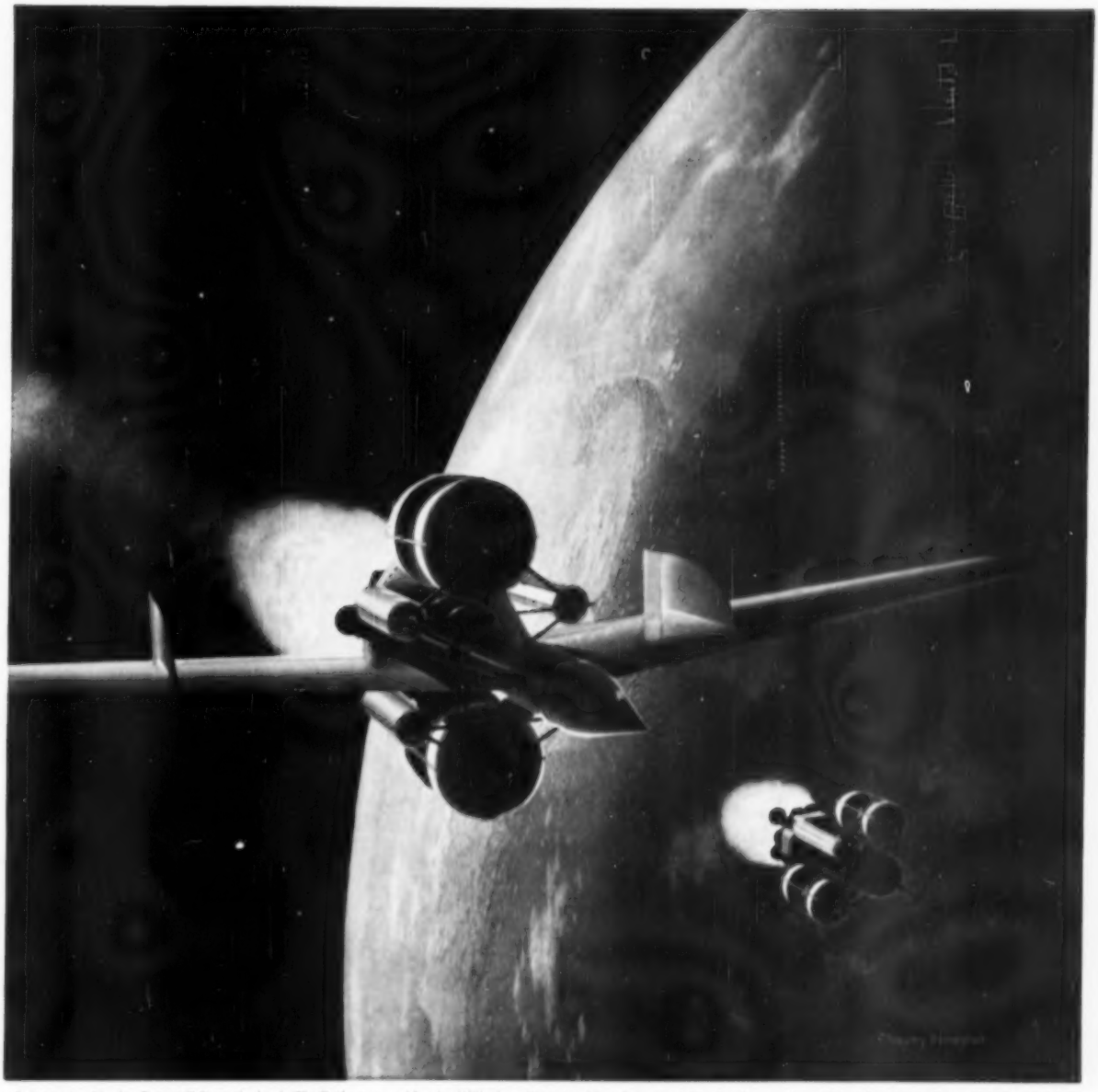
• **Determining engine component performance.** These tests are aimed at checking the performance of engine components, such as compressors, turbines and combustion chambers, to determine their effect on overall engine performance. Tests also assess general performance of these components in relation to the current state of the art in gas turbine design.

• **Checking causes of engine failures,** malfunctions or shortcomings in service. Tests involve operating engines under environmental conditions which are suspected of having contributed to deficiencies of the powerplant in actual service. Analysis of these tests helps to develop fixes.

• **Determining adequacy of fixes.** After an engine's shortcomings have been pinpointed and fixes devised, the fixes are incorporated in the powerplant and it is run under the same environmental conditions which caused the original deficiency, to determine whether the fix is adequate.

The vast gas turbine engine test facilities at NATTS include some never tried before—at least not in the sizes used here. Among them are:

• **Turboprop test cell.** This is the only



Painting by Chesley Bonestell from the book *The Exploration of Mars* by Willy Ley, Wernher Von Braun and Chesley Bonestell, published by Viking Press ($4.95). ©C.B.

Space . . . Time . . . and Temperature . . . with Fenwal aboard

Space and time accommodate no man. But temperature is a little more obliging.

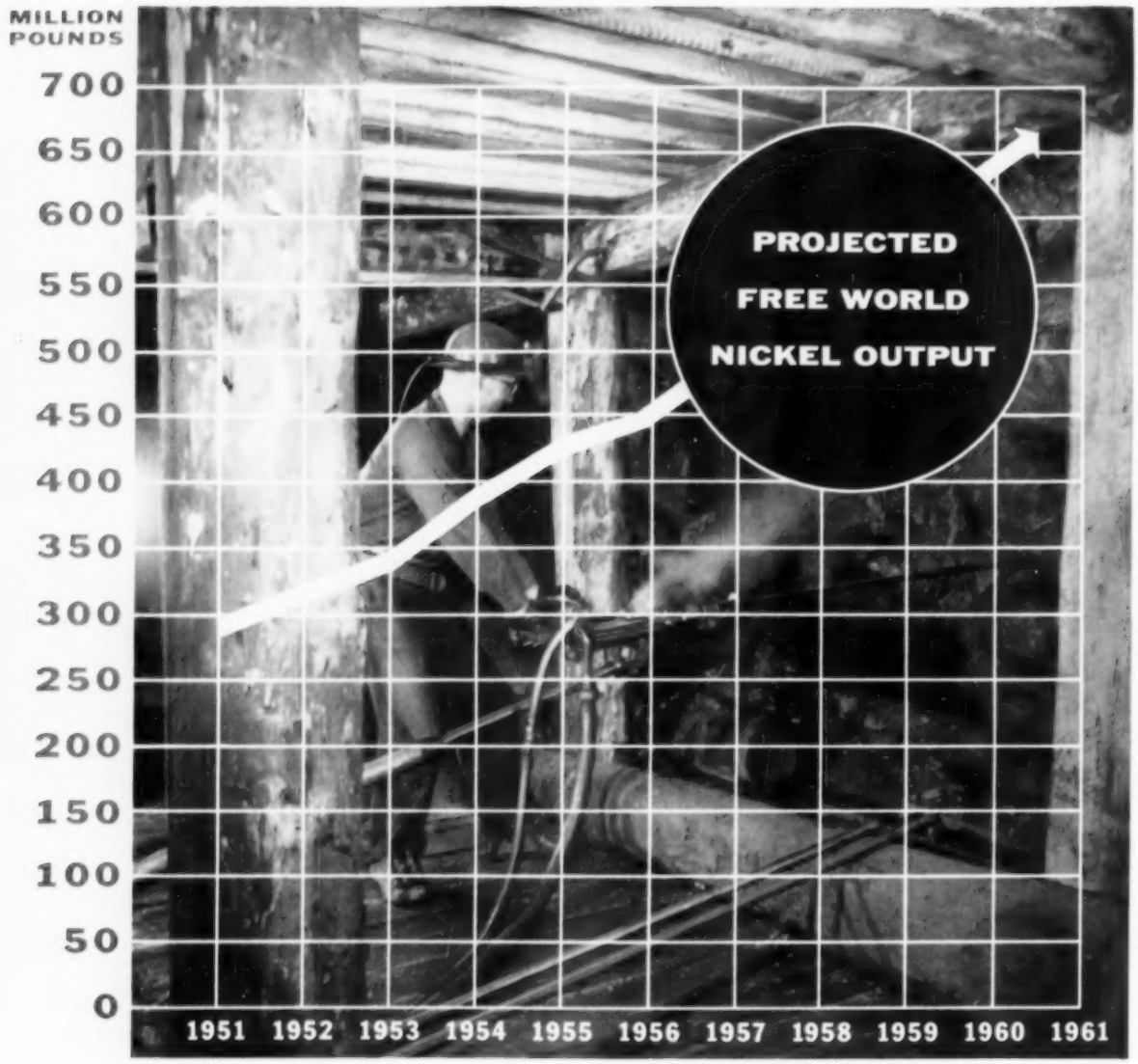
Space ships probably will have miracle-metal blinds that open automatically on the part of the cabin exposed to sun rays and close on the cold side. Who will make the temperature controls? Fenwal, it is likely.

That's because of the advanced job Fenwal has been doing on modern aircraft and missiles. Not only have the temperature sensing problems themselves been solved practically and reliably — but the factors of continued good service under shock, vibration and extreme climatic conditions are being met also.

A good example is Fenwal's leadership in differential thermostats, controls for camera compartments, cooling effect detectors, bearing over-heat alarms and other specially packaged controls. What we do today is preparing us for tomorrow.

To enlist Fenwal's ability to help meet *your* present and future control problems, write Fenwal Incorporated, Aviation Products Division, Ashland, Massachusetts.

Fenwal *Controls Temperature . . . Precisely*



Another 50% advance in nickel industry's production capacity

Paced by Inco-Canada's new developments in Manitoba, producers put 1961 Free World nickel output at 650-675 million pounds a year—up 130% over 1951

In 1951, the nickel industry of the *Free World* produced about 290 million pounds of nickel.

Last year, the over-all output of the industry set a new record high of 450 million pounds.

This was an expansion of more than 50% in five years: a substantial production boost that indeed benefited industry, but only after vital defense and government stockpile needs were given preference.

New Inco-Canada developments help set new goals

Right now Inco-Canada, with years of exploration behind the project, is pushing construction at its new Manitoba mines: developing in the far North a new, big-tonnage nickel-producing area.

In Ontario, at the same time, Inco-Canada is continuing to expand its Sudbury capacity.

In 1961, this should lift Inco-Canada's nickel output to 385 million pounds a year. A hundred million more than in 1956!

With the steadily increasing capacity of all *Free World* producers, in the next four years nickel production should be lifted to the all-time high of 650-675 million pounds a year.

With 1961 capacity anticipated at more than twice what it was in 1951—and with continuing exploration—nickel users are assured of more nickel in their future.

The International Nickel Company, Inc., New York 5, N.Y.

1957, I.N.S. Co., Inc.

INCO **International Nickel**

The International Nickel Company, Inc., is the U. S. affiliate of The International Nickel Company of Canada, Limited (Inco-Canada)—producer of Inco Nickel, Copper, Cobalt, Iron Ore, Tellurium, Selenium and Platinum, Palladium and Other Precious Metals

cell of its kind known to the Navy that is capable of subjecting complete turboprop engines to wide extremes of altitude and temperature. It incorporates a unique inlet throat with a variable orifice which can be adjusted to accommodate a wide range of propeller diameters.

• **"Characterized" valves** of outsized dimensions. These highly sensitive devices regulate air flow into jet engine test cells with very rapid rate of response and a low pressure drop. These valves are among the items which have been giving the Navy trouble. They have "required revision and adjustment," according to a NATTS officer.

Unless the characterized valves function correctly, constant altitude and desired environmental conditions cannot be maintained in the test chambers.

Great amounts of air—total compressor capacity is 1 million cfm.—must be moved through the laboratory to simulate conditions met by jet engines in actual operation.

Air must be moved some 700 ft. through the facility's three buildings—the blower, test and exhauster wings. Some of the components used to move the huge amounts of air required include 23-ft. diameter intercoolers to warm or cool the air, and 48-in. diameter headers.

In the area between the test cells and exhauster wing, specially designed coolers can knock down temperatures of jet engine exhausts from 3,500F to 175F in the distance of a few feet.

Power required by the station started at 40,000 kw., will increase eventually to 100,000 kw. With all the machinery in operation, the test facility has a connected working load of over 100,000 hp.

Control Center

Heart of the test station is a supervisory control room at the front of the test wing. Here a 35-ft. wide central control panel allows engineers to supervise the functioning of every part of the laboratory, by the use of lights, dials, gages and controls.

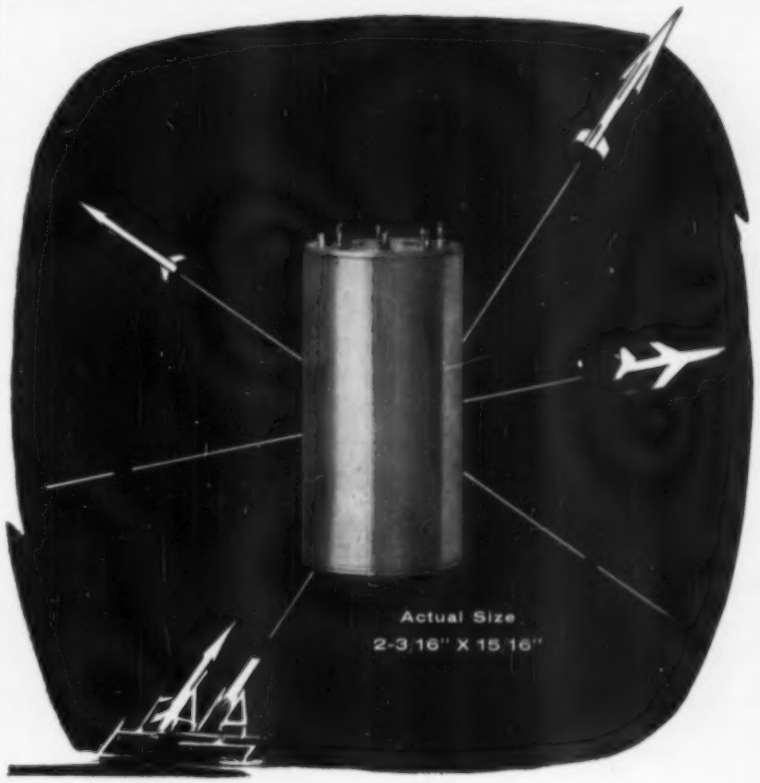
Engineers do not control any of the machinery in the laboratory. They merely give permission to on-the-spot operators to set it in motion when all starting conditions have been met, and act as coordinators to assure that all parts of the complex laboratory function with precision.

Any emergency can be spotted immediately in the supervisory control room, and the push of a single button can shut down the entire laboratory. Controls were designed and installed by Minneapolis-Honeywell Regulator Co.

Indicators on the control room panel check 348 temperatures throughout

Now in mass production . . .

SANDERS Subminiature RATE GYRO



To meet the growing demand for reliable control and stabilization elements, Sanders Associates is now mass-producing the Sanders sub-miniature rate gyroscope.

Exacting applications in aircraft, missile and fire control have proved conclusively the complete reliability of this rate gyro in a wide range of conditions and environments. Its features include:

- **Torsion bar suspension for fast response to minute signals**
- **Resolution of 0.001% full scale**
- **Compensated for environmental conditions**
- **Fluid cushioning to minimize vibrational shock**
- **Rotary multi-pole differential pickoff for higher sensitivity and excellent resolution**
- **Full scale ranges available up to 400° per second**

Sanders' direct distribution offers the long experience of Sanders engineers. Their assistance can be invaluable in reviewing your gyro design and application problems. Whether your problem is on selection of a gyro or a complete gyro control package, our Application Engineers are available to serve you.

SANDERS ASSOCIATES INCORPORATED Dept. AW-6, NASHUA, NEW HAMPSHIRE

West Coast Field Office: 7335 VAN NUYS BLVD., VAN NUYS, CALIFORNIA, Tel. STATE 0-2720

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1 B-47 STRATOJET

While building more than 1,500 Y-4 bombsights for B-47 Stratojets, we improved original design, exceeded USAF specifications. Thorough testing at all stages of production assured perfect assemblies. *We delivered on schedule!*

2 B-52

We make Hemisphere Sights for the MD-9 tail defense system in the B-52 Intercontinental bomber. This optical gunsight has a high degree of electronic automation. It calls for exacting manufacturing and environmental testing.

3 B-58 HUSTLER

The B-58 Hustler, the world's first supersonic bomber, carries a series of key assemblies engineered and produced by the Mechanical Division under sub-contract for Emerson Electric Corporation. Military security prevents detailed description of these ultra-precise electro-mechanical units.

CLASSIFIED

These are some of the men, recognized leaders in their fields, who head the integrated departments that team to provide complete systems service.

From the left: Dr. Howard H. Baller (radar and countermeasures, computers); Dr. Cledo Brunetti, Managing Director of Engineering, Research and Development (electronic design, automation); Donald F. Melton (nuclear handling, automation equipment); Dr. John E. Barkley, Director of Research (solid state, infrared); Zeke Soucek (seated), General Manager; Dr. Carl L. Kober, Director of Development (radar, infrared and inertial systems); Harold E. Froehlich (balloons and meteorological systems); Dr. Otmar M. Stuetzer (microwave optics, semi-conductor physics); Dr. Gottfried K. Wehner (behavior of metals in space flight).

3 GOOD REASONS

for investigating our engineering and production capabilities

The top three United States Air Force jet bombers employ bombing or fire control systems produced in part by the Mechanical Division of General Mills.

Our exceptional combination of engineers and technicians, working as a unified team, can start from any stage in aircraft and missile systems and sub-systems: scientific research, development and design, production engineering or precision manufacturing.

Our other immediate activities encompass development and production of guidance systems for missiles, including the Matador II. We are also doing developmental work in underwater ordnance, radar and infrared.

We'd like to tell you more about how we combine conception with completion to provide *complete* service on major assemblies and sub-systems. We're anxious to answer your questions. Write for descriptive literature.

MECHANICAL DIVISION General Mills

Creative Research and Development • Precision Engineering and Production

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Beware of the Snark!

The nation's first intercontinental missile . . . the Air Force's Northrop Snark SM-62. Equipped with a nuclear warhead, the Snark is a so-called air-breathing missile which travels in the earth's atmosphere. Its compact design presents a smaller target for radar, interceptors, or anti-aircraft missiles.

Extremely mobile, the Snark can be air lifted to any site within a few hours.

The pilotless bomber is powered by a Pratt-Whitney Aircraft J-57 turbo-jet engine equipped with a Holley compressor bleed governor. It flies in near-sonic speeds above the weather over the longest range yet possible by a missile in the free world today.

Like all Holley engine controls, the compressor bleed governor is dependable, easy to service, compact and lightweight – four vital qualities for aviation equipment.

HOLLEY Carburetor Co.

LEADER IN THE DESIGN, DEVELOPMENT, AND MANUFACTURE OF AVIATION FUEL METERING DEVICES.

11955 E. NINE MILE ROAD, VAN DYKE, MICHIGAN

A-25

the facility. Another 300 temperatures can be verified by a standard dial telephone incorporating a special check system.

Laboratory personnel in individual, sound-proofed control centers located close to each test cell operate the engines and watch the tests through elaborate instrumentation and physical observation.

Operating personnel can communicate with each other only via the central control room, allowing engineers to monitor every word that is said. The engineers can talk with anyone in the laboratory through a closed loop communications system.

Blower Wing

Blower wing houses three large Ingersoll-Rand high pressure centrifugal blowers.

Air is taken in through intake silencers. Silencing provisions alone at NATTS—for air intake and exhaust mufflers and sound attenuation equipment—cost more than $3-million. Air is filtered and pumped through primary coolers which dehumidify and cool it to 40F.

It then passes through secondary coolers which can drop the temperature to minus 23F.

From the secondary coolers, air passes into five headers, each having a characterized valve and a 23-ft. diameter intercooler. The valves may be actuated manually through a pneumatic system, or automatically through an electro-hydraulic control system.

Intercoolers warm or cool the air flowing to the test cells to simulate ram heat or altitude cold.

Also housed in the blower wing are large Freon and brine refrigerating machines and associated feeder lines.

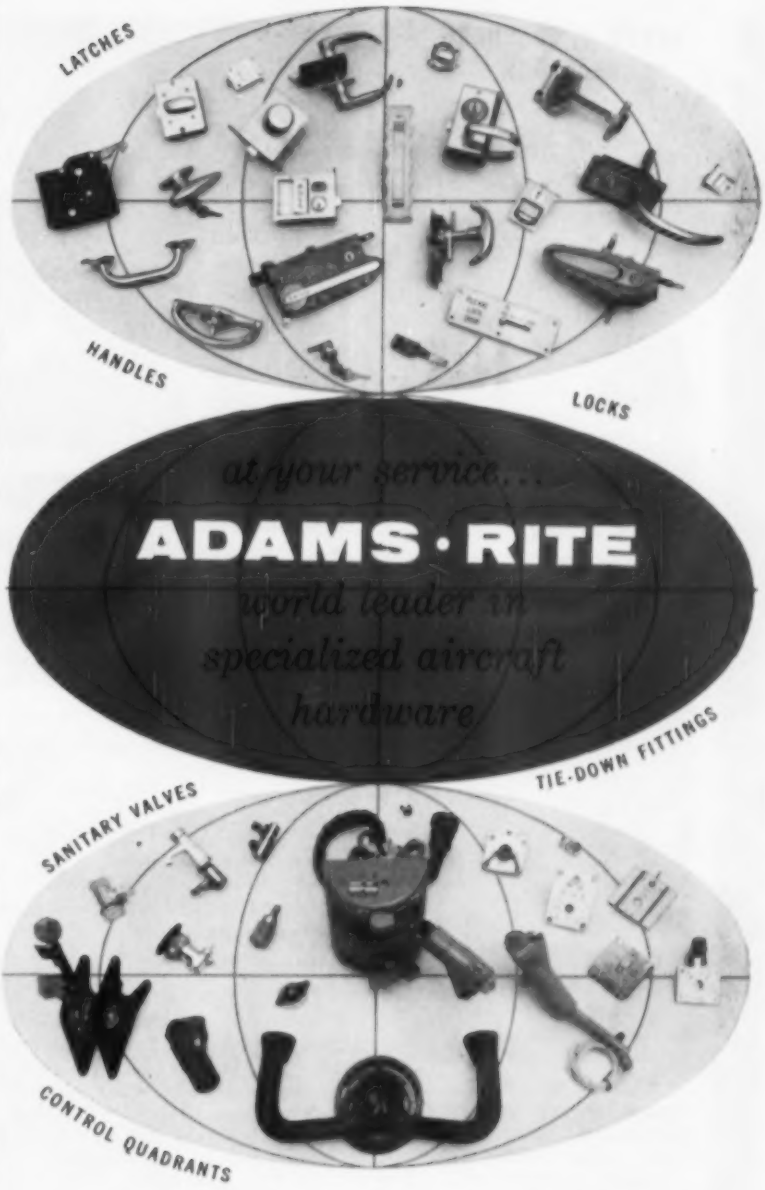
Turboprop Test Cell

Air from the blower wing is pumped into the test wing, which houses five test cells—one for turboprops, two for altitude turbojet testing and two for sea level turbojet testing. Navy says ground will be broken soon for a third, larger high altitude test chamber.

Turboprop test cell, most unique of the three types of test chambers at NATTS, can check engines with conditioned ram air under high altitude conditions, or under ambient air pressure and temperature conditions. Propellers turn in ambient air only.

Props draw in air through 30-ft. high acoustical baffles which act as silencers. A variable-orifice inlet directs the air to the prop. Its circumference can be adjusted to accommodate propeller diameters ranging from 9 ft. to 20 ft.; purpose is to eliminate inlet buffeting around prop blade tips.

Whole orifice structure can be moved back and forth to accommodate turbo-



From Adams-Rite comes the distinguished interior hardware used in the world's new jet transports. The reason is clear . . . today, as for more than twenty years, Adams-Rite Hardware is standard on the planes of every major aircraft company, both military and commercial. Whatever your requirements in aircraft hardware or electro-mechanical control systems, our engineering staff can co-operate with your own to provide the utmost in design, workmanship, economy, and performance. Consultation involves no obligation—inquiries on your company's letterhead will be answered promptly.

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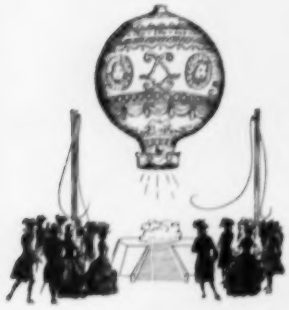
UPPER ATMOSPHERE RESEARCH



The International Geophysical Year is a period of intensive research devoted to the earth and its surroundings. Aerojet-General research rockets will play a major role in IGY. In addition to Project Vanguard propulsion systems, Aerojet will supply its famed Aerobee-Hi rockets for critical research flights from Hudson Bay.

Whether your interest lies in Vanguard or valves, Aerojet-General offers a variety of challenging assignments for:

Mechanical Engineers
Electronic Engineers
Chemical Engineers
Electrical Engineers
Aeronautical Engineers
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Metallurgists
Chemists
Physicists
Mathematicians
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Write: Director of Scientific and Engineering Personnel, Box 296N, Azusa, Calif. or Box 1947N, Sacramento, Calif.

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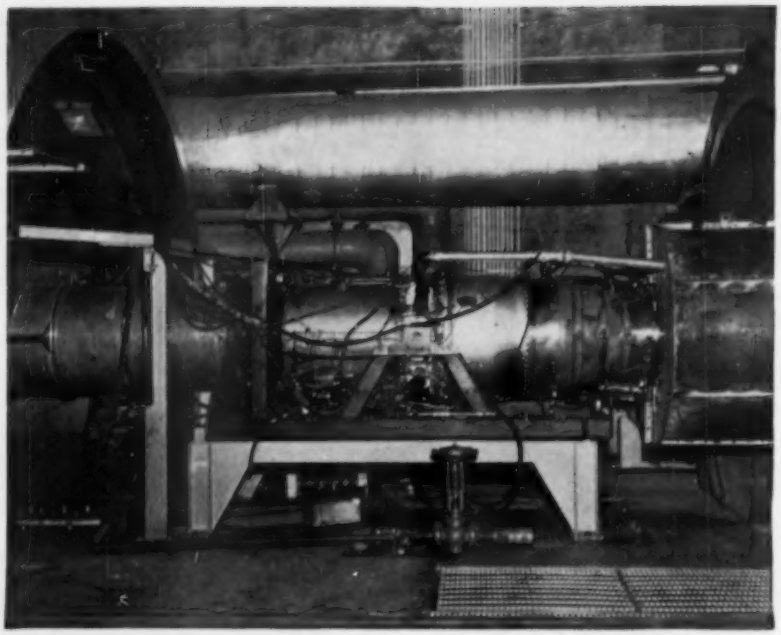


CURTISS-WRIGHT J65 engine installed in altitude test chamber at NATTS.

prop engines of different lengths.

Engine exhaust is drawn into the exhauster wing. Prop wash is blown through a sound-attenuation chamber, where noise is reduced to a level equivalent to hearing the turboprop from a distance of four miles.

Engines are mounted on a cable-supported stand equipped with a thrust measuring mechanism.

Altitude Test Cell

Existing altitude test cells are metal cylinders 65 ft. long and 15 ft. in diameter. Center section telescopes over the forward part to allow the jet engine to be mounted on a thrust measuring stand inside the chamber.

Navy says that deflection caused by mounting heavy jet powerplants on a cantilever platform 30 ft. long creates alignment problems between the telescoping center section and fixed front and rear portions of the cell. To correct this, future altitude chambers will have hinged instead of telescoping access sections.

After the engine has been installed and all fuel, ignition, control and instrumentation hookups made, the center section is positioned hydraulically and secured to both fore and aft sections by means of a mechanical, wedge-type lock. Specially-designed, inflatable rubber seals make front and back joints airtight.

A special partition, tailored to the outside diameter of the powerplant being tested, seals the area between the forward part of the engine and the inner wall of the test cell. This diverts all blower air into the powerplant's intakes and prevents dilution of exhauster suction with ram pressure.

The altitude cells can also be used to test engines under ambient altitude and temperature conditions. Under such circumstances, access to the engine is possible through air lock doors in the test chamber's center section.

At present, the altitude test cells will not handle jet engines equipped with afterburners because of the risk of destructive afterburner detonation. Plans are underway to install water spray curtains to break down any such detonation.

Sea Level Test Cell

The two sea level test cells also can operate either on conditioned ram air or ambient atmosphere. Unlike the

Bureau of Ordnance—R & D Funds

(New Obligational Authority)

	FY 1956	FY 1957	FY 1958
Aircraft and Related Procurement	$8,699,065	$2,224,100	$1,444,000
Guided Missiles and Related Procurement	57,097,357	115,190,300	128,341,000
Totals	$65,796,422	$117,414,400	$129,785,000

Globe Aerostatique . . . 1783

Montgolfier's vanguard project

A sheep, a duck, a rooster—the first payload carried aloft for atmospheric research. Louis XVI, his queen and his court, were astonished witnesses as Joseph Montgolfier's smoke-filled balloon rose in majesty 1500 feet over Versailles. The passengers? unharmed (except the rooster, kicked by the sheep).

Project Vanguard, 1957, is an equally momentous "first"—an attempt to place a 21-pound satellite in an orbit 300 miles up. Aerojet-General, designer-builder of the famed Aerobee-Hi, will supply vital second-stage propulsion systems for Vanguard launchings during the International Geophysical Year.

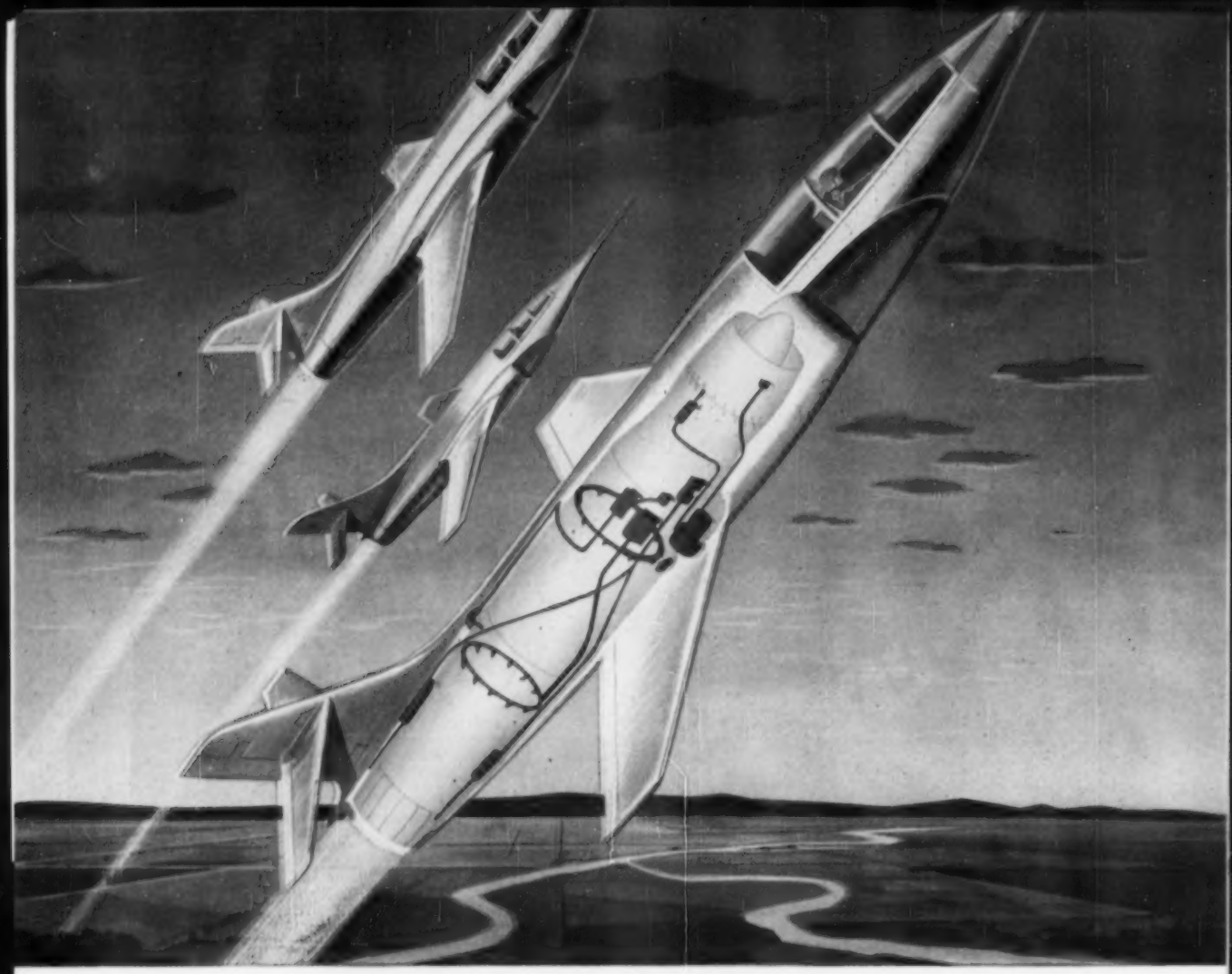
Aerojet-General CORPORATION

A Subsidiary of The General Tire & Rubber Company

THE GENERAL TIRE

PLANTS AT AZUSA AND NEAR SACRAMENTO, CALIFORNIA

Aerojet-General invites scientists and engineers—men of imagination and vision—to join the attack on the most significant research, development and production problems of our time.



TOWARD MACH 3

WITH A COMPLETE BENDIX SYSTEM FOR FUEL METERING AND ENGINE CONTROL

When the pilot swings the lever from idle to emergency thrust—or back again—things must happen fast in the big jets.

But not too fast!

For, pouring it on, or cutting back faster than the engine can take it, spells disaster. The penalties are ruinous over-temperatures, compressor stall or flame-out.

When the pilot orders a change in thrust, the Bendix* fuel metering and engine control system takes over. Fuel feed is automatically computed and scheduled. Geometric controls such as exhaust nozzle area and inlet vane angles are set. Automatically and instantly, engine response is crowded to the limit—but not beyond!

Matched sets of Bendix components—pressure and temperature sensors, electronic amplifiers, fuel metering units and engine control actuators—work together as a *system*, spanning the length and girth of the engine.

Bendix components, designed and engineered together, invariably give more efficient performance than any arbitrarily assembled system.

So, when it comes to fuel metering and engine controls, think of a complete and integrated system. Then we suggest you think of Bendix and the Bendix Products Division.

*TRADEMARK

Bendix PRODUCTS DIVISION South Bend, IND.

Bendix
AVIATION CORPORATION

altitude chambers, the sea level cells can accommodate afterburner-equipped engines.

Engine exhaust, instead of being evacuated by exhausters, is dumped into a sound attenuation chamber which deadens the loud roar to the sound level of an automobile exhaust.

Features of the ground level test cell include:

• **Engine cradles** fashioned from hollow steel tubing through which cooling water is circulated in case engine heat becomes too intense.

• **Four water spray rings** located directly behind the engine to cool the exhaust and prevent damage to the sound attenuation material. Automatic temperature-sensing equipment, supplied by Minneapolis-Honeywell, cuts in the first spray ring when exhaust temperatures reach 380F. Successive rings go into operation until temperature climbs to 460F, when an alarm is sounded.

Exhauster Wing

Exhauster wing, whose control system also gave the Navy trouble, contains large De Laval turbo-exhausters, set up in three stages. Electric motors of 4,500 hp. power each one.

First stage can stimulate altitudes up to 23,000 ft. Second stage goes to 44,000 ft. and the third stage to 65,000 ft.

All exhaust air pumping equipment in the building is interconnected by large-diameter headers. Air flow is controlled by oversized gate valves—some three stories high.

Other equipment in the building includes exhaust silencers, coolers and an extensive air circulation system to ventilate the structure.

Support Equipment

Much support equipment is required to record, collate and interpret the vast amounts of data collected from the test cells.

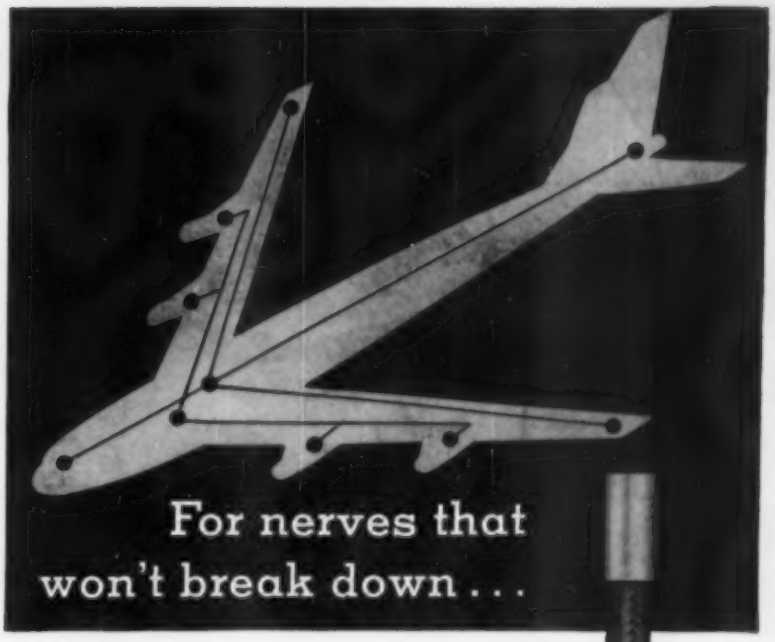
This includes:

• **Davies magnetic tape recorder** with two seven-channel recorders, three-speed play-back system and an X-Y plotter for studying compressor stall and blade stress phenomena in operation.

• **M-H equilibrium data** recording systems. These are contracted for and are nearing completion. Each will be capable of sensing 300 data variables, which are stored simultaneously and then sequentially read out on punched tape for printing or IBM calculations.

• **IBM data processing** equipment is being added to increase the effectiveness and utilization of the establishment.

Goodyear Aviation is supplying GEDA 14 analog computing equipment for engine or accessory simulation work. ■



. . . specify

REVERE TEFLON* CABLE

Electronic cables, the "nerves" of monitoring and testing systems in missiles, rockets and aircraft, are constantly being stressed by the searing heat around jet engines . . . the sub-zero cold of the stratosphere . . . immersion in fuels, chemicals or solvents. Revere Teflon Cable meets these high service requirements . . . and those of computer and radar applications, too.

Revere Teflon Cables are available with 1, 2, 3 or 4 teflon-insulated, silver plated, stranded copper conductors, rated for continuous operation from —90°C. to +210°C. Cables are shielded with silver plated copper to give 90% coverage. Jackets to suit application — silicone treated glass braid, teflon, Kel-F**, vinyl, nylon, etc.

Conductor size: 24 to 18 gage in .008" (300 volt), .010" (600 volt) and .015" (1000 volt) wall thicknesses. Ten and fifteen mil wall conductors meet applicable requirements of MIL-W-16878, Type E and EE.

*E. I. du Pont trademark
**M.W. Kellogg trademark
† Wire passes 500 hr., 250°C heat-aging test
. . . also cold bend test

TYPICAL SPECIFICATIONS — Single Conductor Teflon Insulation

Spark Test Voltage	3000 volts
Insulation Resistance	Greater than 10^4 megohm/1000 ft.
Continuous Operating Range	—90°C. to +210°C. (†)
Dielectric Constant @ 1 MC/Sec	2.5 maximum
Power Factor @ 1 MC/Sec	Less than 0.0003
Flammability	Does not support combustion
Shrinkage	Less than 1/8" in 18" @ 250°C for 96 hrs.
Abrasion (per MIL-T-5438)	Passes 38" of 400 grit, aluminum oxide, ½ lb. weight
Moisture Absorption	0.0%
Specific Gravity	2.2 average
Chemical and Solvent Resistance	Excellent

Write today for Engineering Bulletin 1905 describing Revere TEFLON CABLE.

36

Revere CORPORATION OF AMERICA

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◄— Circle Number 76 on Reader-Service Card

NEW GENERAL ELECTRIC laboratory will speed evaluation of complete airborne electric systems and will allow close coordination of electric system development with the aircraft and related systems and components.

GENERAL ELECTRIC ANNOUNCES . . .

New Aviation Lab to Help Speed Development, Qualification of Complete Electric Systems

To provide thorough evaluation of complete electric generating systems in terms of specified performance under normal operating conditions, and safety under abnormal conditions, General Electric has established a new aircraft electric systems laboratory at Waynesboro, Virginia. This new lab complements existing component development facilities for generators, controls, hydraulic and air turbine constant speed drive equipment, and will help speed completion of current and future programs in these four basic areas:

1. Determination of component compatibility.
2. Development and evaluation of new systems.
3. Qualification testing and reporting on complete systems.
4. Co-ordination and assistance in developing components related to the electric system with customer personnel.

Capacity for future systems

To meet the requirements of these programs both now and in the future, the new lab incorporates advanced, high capacity equipment. Currently up to six systems rated to 60 KVA or three rated to 120 KVA can be evaluated.

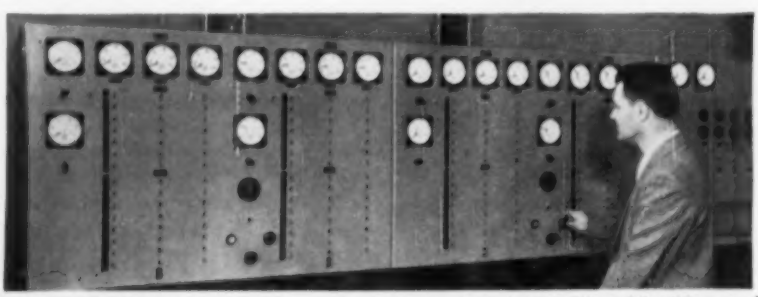
Three drive stands provide adjustable speed at rated power (200 hp continuous, 300 hp for 5 minutes, and 400 hp for 5 seconds) from 4000 to 12,000 rpm at the dual head output shafts. The horsepower varies linearly with rpm at lower speeds. A lab system supplies oil at adjustable temperatures up to 400°C to the hydraulic drives and oil-cooled generators mounted on the output pads.

A heavy flywheel serves to "stiffen" the drive, giving a truer representation of the high-inertia of jet engines. This flywheel is detached to allow evaluation of constant speed drives under conditions of high acceleration.

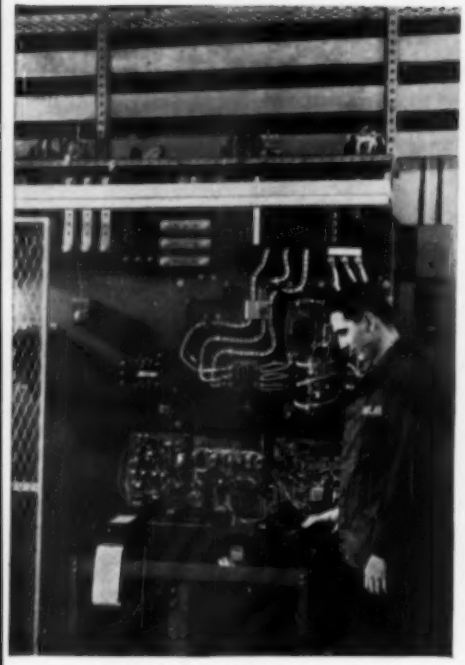
New drives help simulate jet engines

Each drive stand is equipped with a General Electric, current-controlled *Thymo-trol*® drive. This advanced system can simulate the actual rate of change in engine speed or provide the response needed in component testing. Outstanding features include excellent speed regulation, high steady state accuracy, and wide speed range. Acceleration and deceleration rates are adjustable or can be preset from 0 to above 1500 rpm per second. Speed regulation from no load to full load is one percent of base speed. Line voltage variations of plus or minus 10 percent

®Reg. trade-mark of General Electric Co.



SYSTEM MONITORING during development and functional checks is facilitated by this control panel. Switches allow continuous adjustment of the load banks up to 120 KVA.



OVERHEAD ALUMINUM troughs help simulate aircraft conditions by duplicating feeder installation impedances. Control and protective units are mounted on peg board for easy access.

will cause a change in output speed of less than one percent of base speed.

In addition to high efficiency, the new system provides regenerative braking for rapid slowdown. True reversing is possible without the addition of a reversing contactor. Other features of this all-electronic control include either constant horsepower or constant torque, and current, voltage, and acceleration limit protection.

Instruments speed evaluation

The control panel mounts instruments used to monitor system values during development and functional checks as well as providing drive stand control. Switches on the panel control the load banks which are rated 120 KVA at 0.75 power factor per section and are continuously adjustable. A separate panel is used to mock-up the instrument panel exactly as it is proposed for each airplane.

To simulate aircraft generator feeder installations, aluminum troughs are installed above the control mock-up board. Aircraft type cables are installed in the same manner as on the airplane with the trough acting as the skin of the airframe. This method has produced very satisfactory results. Measurements made of the positive, negative and zero sequence impedances of lab installations show close correlation to calculated aircraft installation values.

A high degree of flexibility for interconnecting buses and load banks is furnished by load breakers connected to each generator bus. High current capacity circuit breakers allow application of faults at numerous points in the system.

Current Results of Lab Tests

A typical example of determination of component compatibility through laboratory testing is the development of the parallel operated, 20 KVA Constant Frequency Power Packages. This system, including statically excited generators, exciter-regulators, hydraulic constant speed drives, and protective panels, is made up of all General Electric components, developed and manufactured to operate as an integrated system. The newly developed drive uses a governor with mechanical network compensation giving very fast speed responses. The exciter-regulator has proved capable of stabilizing the system under high governor speeds, load changes, and fault conditions.

Development of the high phase take-over voltage sensing principle is another example of progress through laboratory evaluation. Work in systems application problems showed a need for a new method of voltage sensing in order to provide a safer system without impractical system limitations. To meet this need a General Electric regulator was developed to sense and operate on the basis of the highest of the three-phase voltages for all abnormal system conditions and on the average for all normal system conditions. Laboratory system tests proved this method to be a practical solution to the problem and the design is now widely accepted and specified for many applications.

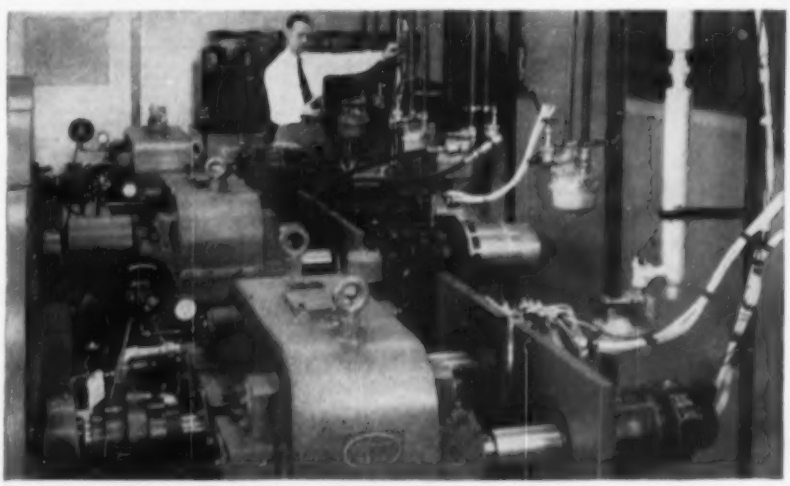
Qualification testing and reporting is another important phase of operations at the new lab. Among the systems currently being tested is the statically excited, 60 KVA, production system for the Lockheed Electra. This relatively small, light weight system eliminates the rotating exciter of conventional generators, allowing reduced maintenance costs, reduced fire hazards, and improved generator cooling and operating efficiency.

Rigorous tests conducted on the system included evaluation of voltage regulation, fault current, response times, protective and transfer functions and coordination of load and system protective devices. Also the lab conducted motor starting and transient tests and short circuit and open circuit examinations of all components.

Another important function of the new lab is to provide assistance in evaluating equipment associated with the electric power system during early stages of development. Typical examples of this service are application of utilization equipment that is unique in its power requirements such as large motor loads and regulated transformer-rectifiers, and the application of circuit protectors in coordination with the over-all protective system.

For more information on General Electric aircraft electric systems, components and development capabilities, contact your local G-E Aviation and Defense Industries Sales Representative. *General Electric Company, Schenectady 5, N. Y.*

210-106



SYSTEMS RATED TO 120 KVA can be evaluated singly or in parallel on these drive stands which provide speeds up to 12,000 rpm. Flywheels simulate high inertia of jet engines.

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GENERAL ELECTRIC

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FREEDOM IS A FRIENDLY SKY

Today, freedom's frontier is the friendly sky you walk under. A friendly sky, like freedom, doesn't just happen. It demands a defense that can halt aggression almost before it starts ... the electronic kind of defense our Air Force is building. As IBM sees it, this is the surest guarantee that our skies will remain friendly ... and free.

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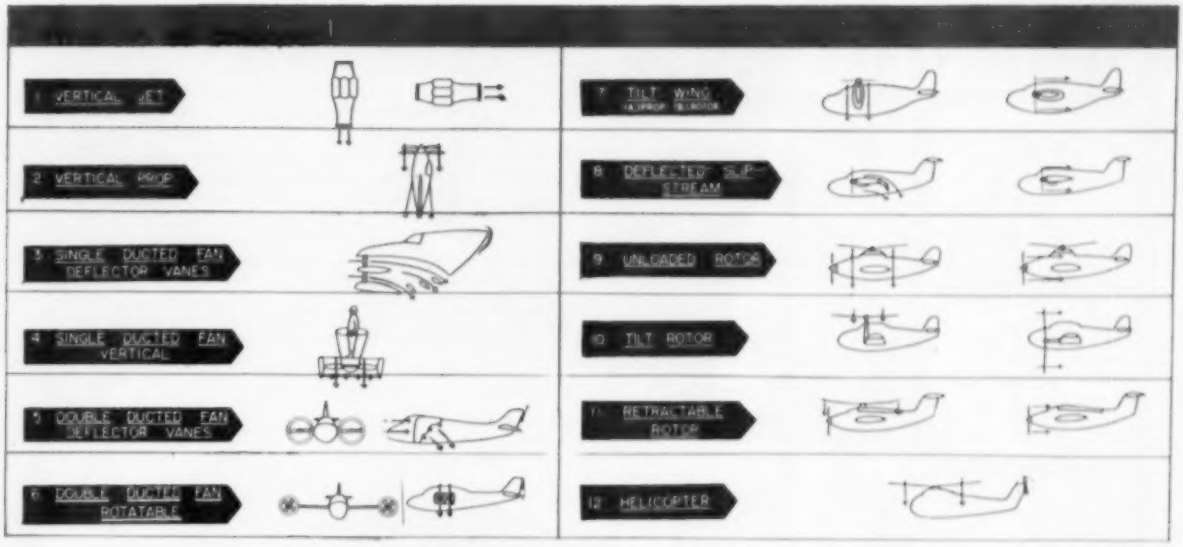


Funds, Rules Limit Army Air Research

By Claude Witze

Ft. Eustis, Va.—The Army Aviation Division of the Transportation Research and Engineering Command (TRECOM) is experimenting boldly with new approaches that have grown out of its ingenuity in meeting a stern set of standards:

- **Rigid economy in design** and development of aircraft. Great reliance is placed on voluntary contractor co-operation.
- **Range and weight restrictions** imposed by the Department of Defense in its definition of the Services' roles and missions.
- **Provision of air mobility** in the battlefield environment of the ground soldier.

It is an area of low flying, slow flying that until now has not attracted attention from the aircraft industry's finest talent.

Frequently overlooked in discussions about research and development for Army aviation is the simple fact that it is more or less verboten, so far as the Army itself is concerned.

Checkreined by Wilson

Defense Secretary Charles E. Wilson has put the checkrein on more than just the range and weight of Army aircraft.

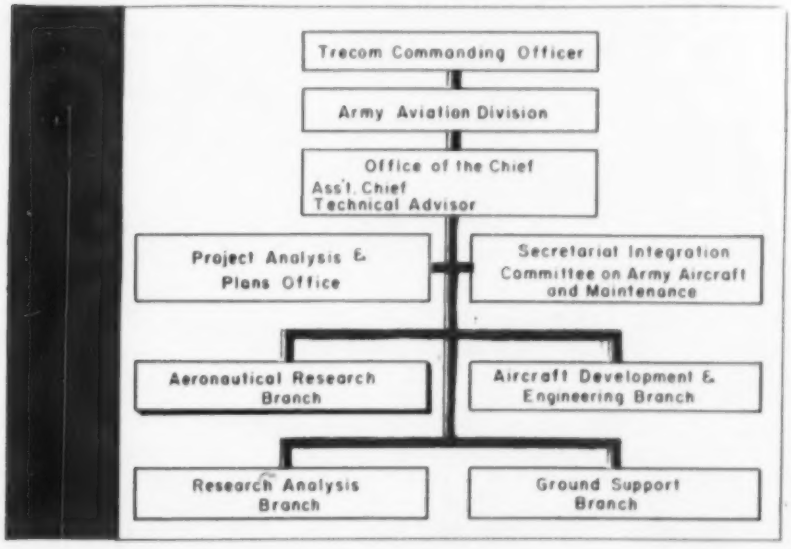
Wilson's famous memorandum of Nov. 26, 1956, confines Army aircraft to a range of 100 miles from the line of battle. It fixes maximum empty weight of aircraft at 5,000 lb. and of helicopters at 20,000 lb.

The Defense Secretary's memorandum also says:

"The Army will not maintain unilateral aviation research facilities but will confine itself to the development and determination of specific requirements peculiar to Army needs, to evaluation of proposals, and to user testing of equipment.

"The Army will make maximum use of Air Force and Navy aircraft research and development facilities. The Air Force and Navy will be responsive to Army needs in such research activities on a reimbursible basis.

"The Army will use existing types of Navy, Air Force or civilian aircraft when they are suitable, or may be suitably modified, rather than attempt to develop and procure new types."



Flying Crane Studied

Effect of this edict is that TRECOM's eight-month-old Army Aviation Division is not a research and development facility or even an agency with the usual prerogatives in this area.

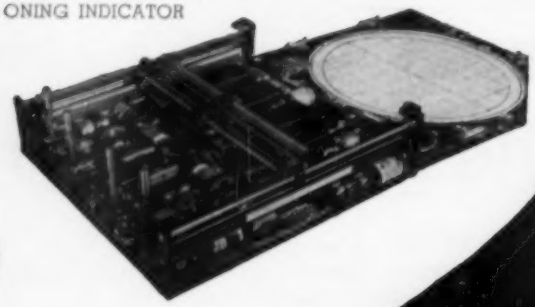
Transportation Research and Engineering Command is an engineering center where a staff of 67 persons investigates new ideas for which the Army may have a requirement.

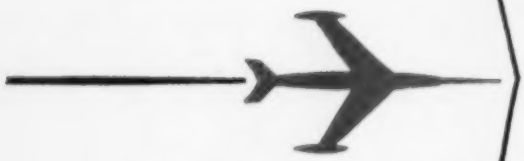
A good example of the way this operates in the case of a specific project is the current parametric design study of a flying crane. In accordance with the Wilson order, TRECOM is trying to find out whether the Army needs such an aircraft—a determination that can be made only after Army knows the exact state of the art, what can be

true flight!

This Pilot's Dead Reckoning Indicator will track an aircraft's true flight over ranges up to 50 miles . . . and will indicate the position, motion and heading of the aircraft in which it is carried by a spot of light ¼ inch in diameter, projected onto the surface of a translucent grid disc. In the center of this spot of light is an arrow that indicates the direction of the aircraft's heading . . . which will rotate through 360°. Using transistors and other miniature components and techniques our Pilot's Dead Reckoning Indicator is the smallest of its type.

PILOT'S DEAD RECKONING INDICATOR





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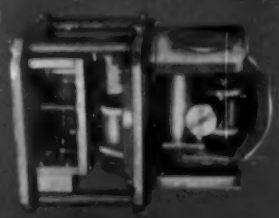
This precision instrument is but one of many which Daystrom engineers have developed—and Daystrom's shop has produced for the Armed Services and industry. You, too, can depend on the "know-how" of Daystrom in development, design and production . . . upon Daystrom's reputation for meeting rigid quality standards and high reliability. Drop us a line, and we'll be glad to have our representative call on you. Or, better still pay us a visit, and see our modern plant and complete facilities.

OTHER NEW DAYSTROM DEVELOPMENTS INCLUDE:



Aircraft All Attitude Indicator

Underwater Servo Control System

Depth Amplifier Test Set

Circle Number 83 on Reader-Service Card

FIRST TILT-WING model ever built was developed by Vertol Aircraft Corp. for Army, Office of Naval Research, declassified recently. It flies horizontally, vertically.

built and how much it will cost to procure and operate.

A few contracts have been granted for paper studies of the flying crane idea by manufacturers with a proven interest and capability. Other designers have been encouraged to offer their ideas on the subject without a contract.

Lifting Tanks and Missiles

Several design ideas have been received. In general, they will provide a helicopter type of lift machine capable of moving tanks over barriers, placing bridges, moving missiles into position. They should have a speed of 50 kts. and carry a payload of 8 to 15 tons, depending on the range.

TRECOM will not reveal details of what is being considered, but proposals already in have been sent to USAF's Wright Air Development Center for concurrent evaluation If the requirement is established–and Army aviation chiefs already have said they need such a device–USAF will draft the final specifications and administer the procurement.

The most significant development in TRECOM's short history may be the fact that it is stirring up the interest of major U. S. aircraft companies. Some of them, standing for years in the gaudy atmosphere of Air Force and Navy weapon development procedures, are stepping down to middle class standards with visits to Ft. Eustis.

This is true in the case of the flying crane, the aerial jeep, multiple lifting devices and the higher performance observation aircraft.

Missiles Are Factor

The shift in emphasis away from manned weapon systems and toward guided missiles is an obvious factor in the change of attitude.

Corollary is that Army has genuine aeronautical problems at a time when

READY-TO-EAT FOOD

● Food is essential! It is basic to efficiency in all we do . . . particularly in times of stress or emergency. The Multi-Meal-Tube, a development of the National Research and Development Corporation, fulfills this basic need.

● The Multi-Meal-Tube contains, ready-to-eat, the equivalent of one complete meal of 720 calories. It provides all the essential food elements required for the maintenance of normal body functions in combination with bulk substances to give roughage residue required for normal gastro-intestinal function. "MMT" requires no refrigeration or special storage.

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AN APPETIZING HIGH CALORIC CONCENTRATED FOOD . . . . ONE READY-TO-EAT MEAL per TUBE
DIRECTIONS: Remove the screw cap and squeeze contents directly into the mouth
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No shock is too much for the Lindsay Pressure Gauge ...proven in guided missiles!

U.S. ARMY PHOTO

The RMC-Lindsay Pressure Gauge registers steady pressure readings from 500 to 10,000 PSI for extended periods. Not even the most extreme conditions of shock, vibration or temperature disturb its accuracy. It is the one high pressure gauge capable of meeting the tremendous demands of guided missile service, and is currently used in some of the nation's mightiest missiles and aircraft.

The RMC-Lindsay Gauge is a bourdon tube gauge which uses a multiple coil, helical bourdon tube with the pointer attached directly to the end of the coil. As compared to the traditional "C" spring bourdon gauge, the life of the Lindsay helical bourdon coil is more than 10 times greater and its proof pressure limits are increased by a factor of 3 or 4. Also, by using the multiple turn helical bourdon tube there are no linkages and pivots—this improves the gauge's shock resistance by a factor of 5 or 10.

The same basic gauge—with all its rugged, missile-service qualifications—is used for aircraft applications. Lindsay Pressure Gauges for aircraft are made for extensive cycling—will meet rigid endurance and over-pressure requirements. They are made in sizes down to 1" diameter.

ACTUAL SIZES

The helical bourdon element is, of course, not a new development. However, the RMC-Lindsay techniques in coiling, heat treatment, calibration and material specifications are new—and exclusive with RMC of California.

Whatever your high pressure gauge problems may be, why not let RMC engineering skill provide the answers. Write today, outlining your particular requirements.

RMC
LINDSAY PRESSURE GAUGES

ROCHESTER MFG. CO., INC.
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Circle Number 98 on Reader Service Card

Surveillance Drone

Washington—Army plans to procure three types of drone aircraft for evaluation in battle area surveillance. Out of them, one type will be selected for Army use.

The drones will be in the medium class, capable of carrying a 100 lb. payload. Cameras, television and radar devices are among the equipment that can be carried.

Brig. Gen. Chester B. DeGavre, director of developments in the office of the Chief of Research and Development, told a subcommittee of the House Appropriations Committee that Army also is experimenting with a "side-looking radar." It is a device that can be flown parallel to the front lines to reproduce a "picture" of enemy territory.

these are being pushed aside elsewhere by the strenuous search for advances in such fields as metallurgy and solid state physics.

Aerial Jeep Evaluated

An evaluation now under way at Fort Eustis involves 28 designs for the aerial jeep, received from 21 contractors. Because this project was launched prior to the Wilson memorandum, it is an all-Army proposal, being studied by TRECOM with a strong lift from its helpful neighbor, the National Advisory Committee for Aeronautics, located a few miles away at Langley Field.

The aerial jeep will incorporate two or more ducted fans of the type already flown in the Hiller Flying Platform. Typical entry is 10 by 20 ft. in size, grosses 2,500 lb. and can carry a 1,000 lb. payload. It has a low silhouette. Range is limited to 25 mi. and speed to 30 kts. It is capable of mounting radio equipment, machine guns, or a 106 mm. rifle.

Many of the 28 designs now under consideration came from industry volunteers who were urged to study the Army's special problem and suggest a solution.

Naturally, their proposals are less complex than a full design, but they must contain enough information to permit sound evaluation.

Contract Due By July

TRECOM hopes to let a contract for one vehicle before the end of the current fiscal year. It is anticipated that USAF or the Navy will write final specifications if Army decides to procure an end item.

Other current projects being evaluated include:

• **Design study of a 250 hp.** free shaft turbine engine. Proposals have been re-

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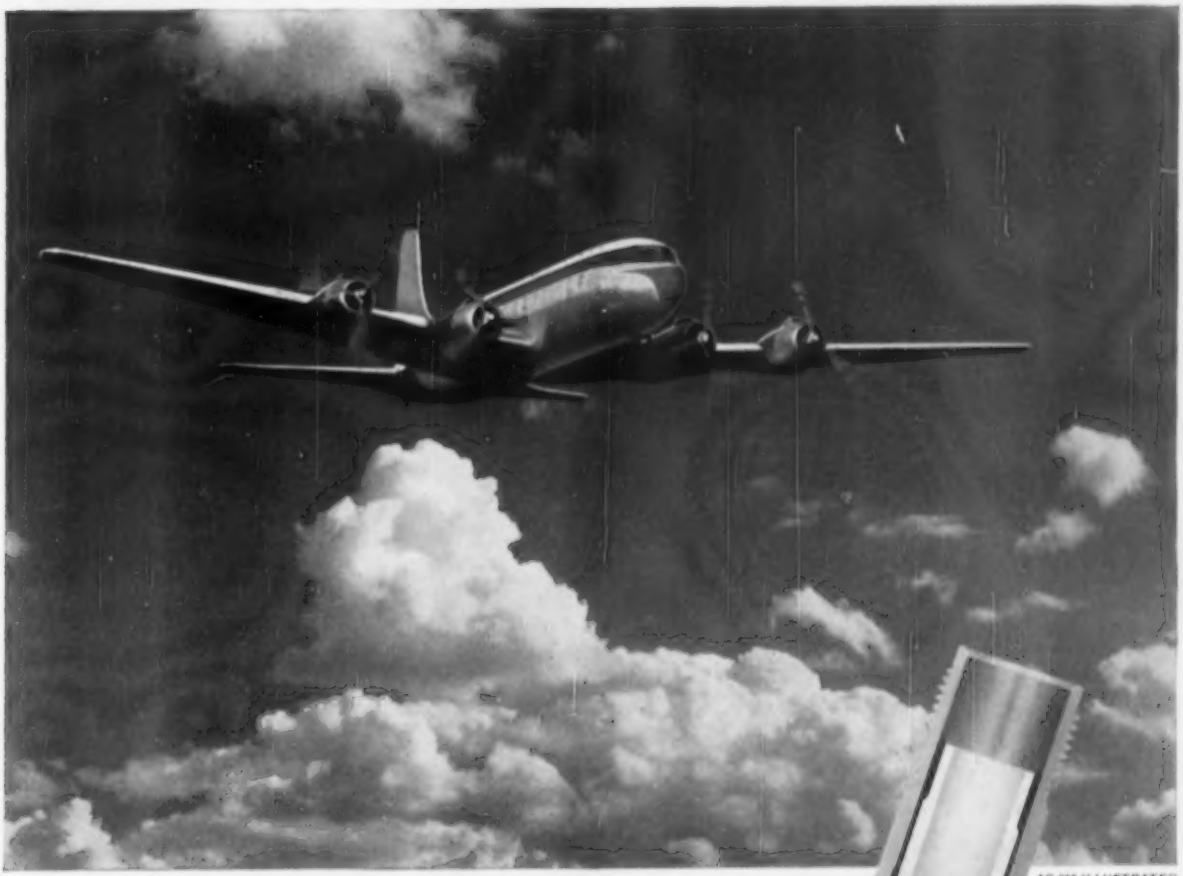

AC-285 ILLUSTRATED

FLIGHT DELAYS DUE TO IGNITION FAILURES ARE DRAMATICALLY REDUCED WITH AC SPARK PLUGS!

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You profit two ways when you fly with AC! First, ignition delays are dramatically reduced because the products of combustion can't get into the barrel to contaminate the insulating surfaces — attack the ignition leads — short the spark plug. Second, the proper heat range of the spark plug is maintained to give you faster starting — smoother operation — greater economy — through longer spark plug life.

All of these features, engineered and developed by AC, have been proved in millions of hours of flight in airline and military planes. You'll find that *leakproof* AC Aircraft Spark Plugs are best for the planes you fly!

AC SPARK PLUG — THE ELECTRONICS DIVISION OF GENERAL MOTORS

FLYING STARTS with GM GENERAL MOTORS

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High-production *quality* welds are easy for the operator who uses P&H Iron-Powder Electrodes. Powdered metal in the coating raises thermal efficiency, providing speed of deposition and bead smoothness that approach submerged arc welding.

Typical applications include railroad cars, construction equipment, bridges, shipbuilding, foundry equipment, tanks, and piping.

Write for Bulletin R-29, "P&H Smootharc Welding Electrodes," for full description and specification data. Address Dept. 312H, Harnischfeger Corporation, Milwaukee 46, Wisconsin.

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ceived from four manufacturers. The unit will have application in helicopters and VTOL/STOL aircraft as well as commercial light planes.

• **Two-man observation helicopter.** Six manufacturers have study contracts to determine feasibility of the idea. Optimistic goal set by Army is to find an aircraft that will cost about a third of present models.

• **Vertical takeoff and landing aircraft.** Test beds are being built by such firms as Ryan Aeronautical Co., Vertol Aircraft Corp., Doak Aircraft Co. and Hiller Helicopters.

Other Agencies Aid TRECOM

In all, TRECOM has about 125 items on its active list, ranging from a study of the effect of atomic blast on Army aircraft to improvement in aircraft mooring equipment.

There are about a dozen test bed projects, a number of them being carried out in cooperation with the Office of Naval Research, Navy's Bureau of Aeronautics or USAF's Air Research and Development Command. Also included are NACA, the Civil Aeronautics Administration and other agencies.

To simplify TRECOM's relations with other agencies and provide a single point of contact, Army now maintains a Transportation Corps Aviation Field Office at the Wright Air Development Center, Wright-Patterson AFB, Ohio. One staff member also is based at ARDC headquarters in Baltimore.

Under the field office at Dayton are project officers located permanently at such standard stations as the Naval Air Training Center, Patuxent, Md.; Bureau of Aeronautics, Washington, and the Air Force Flight Test Center, Edwards AFB, Calif.

Army Aviation Board's Role

Actual military characteristics of new Army aircraft are prepared by the Continental Army Command, Ft. Monroe, Va. Key sector of CONARC is the Army Aviation Board at Fort Rucker, Ala.

The transition here from TRECOM to the board—and back again—is one that must be followed closely by the industry, but the job is made easy. The reason, again, is economy.

An industry briefing program is held at Ft. Rucker at regular intervals. It is set up to permit competent manufacturers to present new proposals and discuss future possibilities.

Authority for this tight liaison between Army and industry is found in the Army regulation on research and development of materiel. The regulation admonishes:

"Any tendency to isolate the using agency from technical problems in-

...for
CRITICAL FASTENING PROBLEMS
specify Delron
specialized fastening devices

High Temp, Self-locking, Stainless Steel Nuts — Free Spinning On Lock . . . Unlock, Free Spinning Off — Reusable.

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(temperatures up to 1200° F.)

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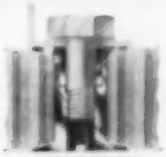
(temperatures up to 1600° F.)

DURA-LOC WASHER-NUT
All-metal, self-locking nut with integral washer. For keyhole type flange mountings at temperatures up to 550° F.

DELRON BOLTS & SCREWS
High Temp, Stainless Steel Bolts and Screws for temperatures to 1600° F. Special thread form minimizes galling.

FASCO THRU-BOLT SPACER



FASCO THREADED SPACER

FASCO THREADED SELF-LOCKING SPACER

FASCO SPACERS for Honeycomb Structural Panels
Lightweight, High Column Strength Aluminum Spacers available in a variety of designs, for assembling and attaching to honeycomb sandwich-type structural panels. FASCO Spacers in various designs and materials can be made available for other types of structural panels including Stainless Steel.

Illustrated are a few of the many Delron Specialized Fastening Devices designed to help solve your critical fastening problems!

Need data on a specific fastening problem?

Clip this ad to your letterhead, and mail for product data on items checked: AW

☐ Fasteners to 1200°F. operation
☐ Fasteners to 1600°F. operation
☐ Sandwich structure fastening

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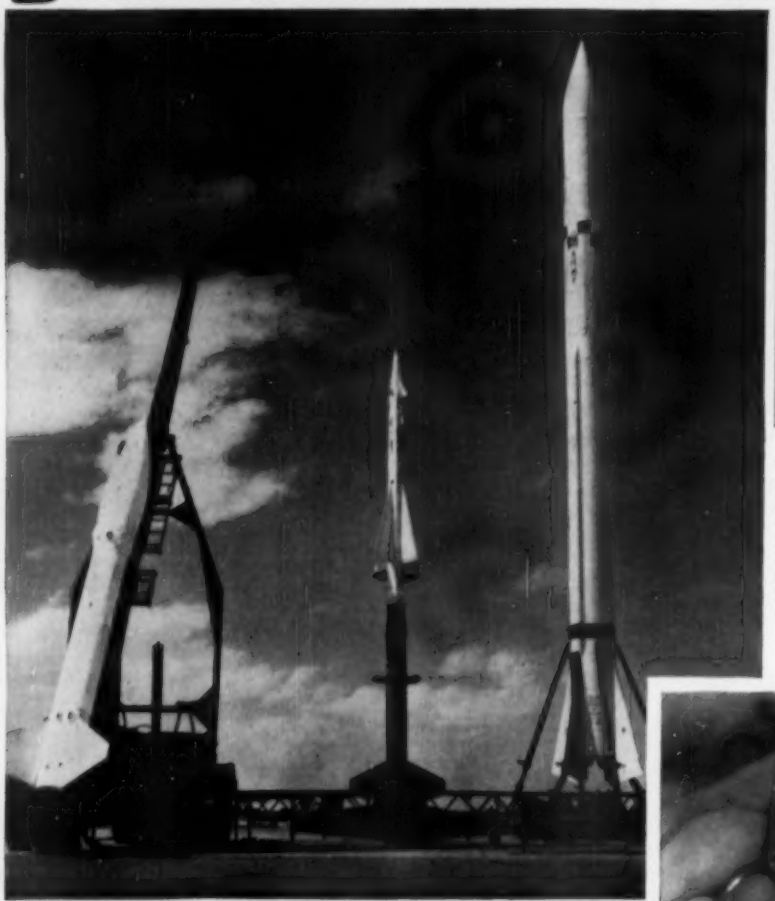
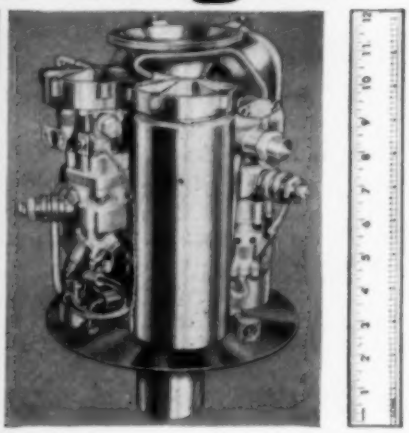
Thompson power units keep guided missiles "on target"!



Army's Production Missiles include the "Honest John" *(left)*, the "Nike" *(center)* and the "Corporal" *(right)*. It is estimated that Congressional appropriations for missile construction in 1957 will be close to 2 billion dollars.



This is one of the Thompson "Muscles" built to help keep guided missiles "on target" with uncanny accuracy. The self-contained auxiliary power plant shown here is only 12 inches high yet it produces approximately 10 horsepower in electrical and hydraulic energy. This power is used for operating the guidance controls, radar mechanism and intricate computing gear of the missile.

100,000 Revolutions per Minute! Yes, the tiny turbine wheel which you see here on the watch-size alternator, spins at the rate of 100,000 RPM . . . almost 1700 per second! It develops electrical current that would be sufficient to light a 100-watt bulb, and is part of a very small Thompson auxiliary power unit for guided missiles. This particular power unit is designed for a useful life of less than a minute!

TODAY'S HEADLINES tell of rocket-propelled guided missiles that soon may be able to travel 400 miles high at 10,000 to 15,000 m.p.h. These fantastic weapons can well be the key to permanent peace among nations.

Now being built for guided missiles are hard-working Thompson Auxiliary Power Units. These busy, complex units supply "muscle" power for steering controls, radar mechanisms and intricate computing gear that guide the missile unerringly to its target, near or far.

Some of these Thompson "A.P.U.'s" can be slipped into your pocket; some are as big as office desks. They range from 100 watts to 60 horsepower in output, and from a fraction of a minute to several hours in predetermined operating life. Each Thompson unit is highly accurate, even at extremely high altitudes and supersonic speeds. It withstands extreme temperatures, rapid acceleration and friction.

Thompson "custom-engineers" every unit. Each is a highly intricate system involving many specialized electrical and mechanical devices, fuel systems and generators. Yet, all are blended into one compact, efficient package to meet the requirements of our defense.

Behind Thompson are 55 years of automotive, aircraft, mechanical and electronic experience. Thompson has the engineering skills and the laboratory, testing and manufacturing facilities to solve complex scientific problems. Many different industries have learned they can *count on Thompson* to come up with parts and components that do the job right. Thompson Products, Inc., General Offices, Cleveland 17, Ohio.

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Circle Number 86 on Reader-Service Card

volved in research and development, or the research and development contractor from user requirements as embodied in military characteristics, introduces inflexibility into the research and development system. . . ."

Visits by contractors to such units as TRECOM and the Army Aviation Board at Ft. Rucker are encouraged.

Military dependence on industry know-how is nothing new. But Army aviation, with its unique interests in a science that is devoting more and more attention to the missile age, provides some real opportunities.

There is strong evidence that industry is aware of this challenge and will meet it. ■

Principal Army Missile Contractors

Future of Army's part in development and use of ballistic missiles, at least those of any great range, has been put in doubt by Defense Secretary Charles E. Wilson's decisions on roles and missions and the upcoming evaluation of the Army Jupiter IRBM against the Air Force Thor 1,500-mile missile.

Meanwhile, Army continues research and development on intermediate range missiles at its Army Ballistic Missiles Agency, located on 3,000 acres of the 40,000-acre Redstone Arsenal at Huntsville, Ala., and through a network of contractors.

Work on its stable of shorter range rockets and missiles, which includes the Hawk, Nike-Ajax and Nike-Hercules, Corporal, Dart, Honest John and Little John, Lacrosse, Sergeant and Redstone, continues at Redstone and through industrial firms. Testing is done at Redstone and at White Sands Proving Ground, N. M., and Air Force Missile Test Center, Patrick AFB, Fla.

Here is a list of Army's principal missile contractors:

Western Electric Co., New York 5, N. Y.
Bell Telephone Laboratories, Inc., Whippany, N. J.
Grand Central Rocket Co., Redlands, Calif.
Aerojet-General Corp., Azusa, Calif.
Thiokol Chemical Corp., Trenton, N. J.
Rohm & Haas Co., Philadelphia, Pa.
Radio Corp. of America, Camden, N. J.
Raytheon Manufacturing Co., Waltham, Mass.
Douglas Aircraft Co., Inc., Santa Monica, Calif.
Rheem Manufacturing Co., Downey, Calif.
Calif. Institute of Technology, Pasadena, Calif.
Carborundum Corp., Niagara Falls, N. Y.
Martin Co., Baltimore, Md.
Cornell Aeronautical Lab., Inc., Buffalo, N. Y.
Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.
Aircraft Armaments, Inc., Cockeysville, Md.
Sanders Associates, Inc., Nashua, N. H.
Sperry Gyroscope Co., Long Island, N. Y.
Eastman Kodak Co., Rochester, N. Y.
General Electric Co., Schenectady, N. Y.
Firestone Tire & Rubber Corp., Akron, Ohio
B. F. Goodrich Co., Akron, Ohio
Santa Barbara Research Center, Santa Barbara, Calif.
Reynolds Metal Co., Louisville, Ky.
Armour Research Foundation, Chicago, Ill.
Gilfillan Bros., Los Angeles, Calif.
Aerophysics Development Corp., Santa Barbara, Calif.
H. A. Wagner Co., Los Angeles, Calif.
Emerson Electric Mfg. Co., St. Louis, Mo.
Franklin Institute, Philadelphia, Pa.
Texas Instrument Co., Dallas, Tex.
Northrop Aircraft, Inc., Hawthorne, Calif.
Food Machinery & Chemical Corp., San Jose, Calif.
Sylvania Electric Products Co., Waltham, Mass.
Bendix Products Division, Mishawauka, Ind.
Allegany Ballistics Laboratory, Ridgely, W. Va.
Caywood-Schiller, Chicago, Ill.
Institute of Cooperative Research, Baltimore, Md.
Olin-Mathieson Corp., New York, N. Y.
Hercules Powder Co., Wilmington, Del.
Consolidated Western Steel, Los Angeles, Calif.
Farrand Optical Co., New York, N. Y.
Goodyear Aircraft Corp., Akron, Ohio.
Bulova Research & Development Corp., Long Island, N. Y.
Federal Telecommunications Labs., Nutley, N. J.
Chrysler Corp., Detroit, Mich.
North American Aviation, Inc., Los Angeles, Calif.
Ford Instrument Co., New York, N. Y.
Stanford Research Institute, Palo Alto, Calif.
Westinghouse Electric Corp., Pittsburgh, Pa.
Motorola, Inc., Phoenix, Ariz.
Cook Research Laboratory, Chicago, Ill.

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5-57

Circle Number 84 on Reader-Service Card

CAA Center Tackles Traffic Control

By L. L. Doty

Indianapolis—Automatic control of air traffic and the introduction of Vortac as a common system are undergoing intensive shake-down evaluations by the Civil Aeronautics Administration's Technical Development Center.

Development of an airways and air traffic control system that is expected to handle more than 30 million take-offs and landings annually within a decade holds top priority among some 55 current projects.

Research and evaluation of an automatic control system has been under way for several years. Work on Vortac ground and airborne components began shortly after Vortac was adopted as the U. S. common navigation system early last fall (AW Sept. 3, p. 41).

Common System Tests

TDC presently is experimenting with airborne, Tacan-compatible DME units and is conducting in-service tests to improve Tacan ground equipment, with emphasis on sighting, distance coverage and high-angle coverage.

Vortac combines the distance-measuring characteristics of Tacan with VOR/ILS. It is a compromise solution to a six-year debate between the military, which favored Tacan, and civil aviation, which advocated VOR/DME.

CAA wants all units fully tested and evaluated before implementation begins, to prevent unnecessary breakdowns of the overall system. A similar procedure was followed in the programs assigned to VOR and ILS before they were installed for general use.

Projected program calls for 1,230 Vortac and 289 ILS-TAC stations by 1965. Funds required by CAA in the next six years for purchase of airways equipment will amount to an estimated $810 million.

Organized in 1939

The Technical Development Center was organized by CAA in May, 1939, for research on and development of projects and products used by CAA in performing its missions. The center is located on the outskirts of Indianapolis' Weir Cook Airport. It employs about 100 technicians, engineers and their aides.

In a first step toward automatic airways control, TDC is developing a semi-automatic air traffic control coordinating system that employs electronic data processing (datamation) to ease the burden of air traffic controllers. Purpose of this part of the system is to eliminate hand-written flight progress strips and the slow transmittal process of filing flight plans and transferring flight information from one control center to another by telephone.

As in the case of other TDC research and development projects, datamation will be introduced piecemeal to simplify transition and provide complete assurance of a fail-safe system.

Under the datamation system, flight plans will be filed by means of a push-button handset, similar to computers recently adopted for airline reservations. Also under study are perforated tapes or punch cards for automatic transmission of information.

To route the data into the proper air traffic control center, automatic teletype switching centers will be installed. Here, information will be fed into a digital computer and a magnetic storage drum.

The computer will determine how many flight progress strips are required for a given flight and at what time the flight will pass over each radio fix.

Teletype printers in each center will print the information on the strips, which will be inserted manually by controllers into strip holders similar to those now in general use.

Here are the equipment requirements for this program:

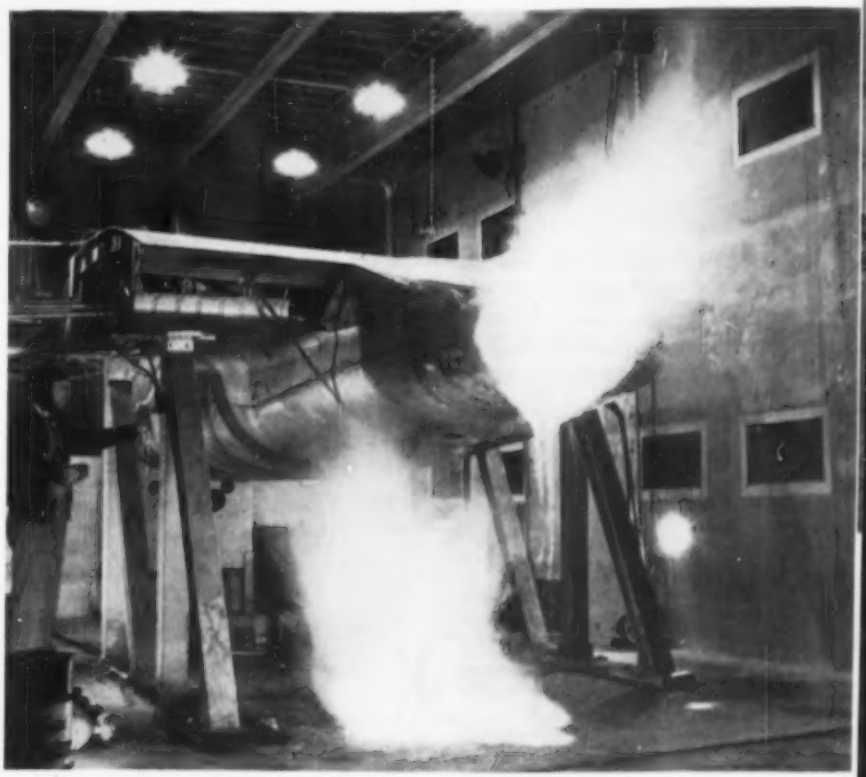
- **Teletypewriter communications system.**
- **Flight-plan input device.**
- **General purpose computer with multiple input and output capabilities.**
- **Automatic printers for preparing flight strips.**

Electronic Display Sought

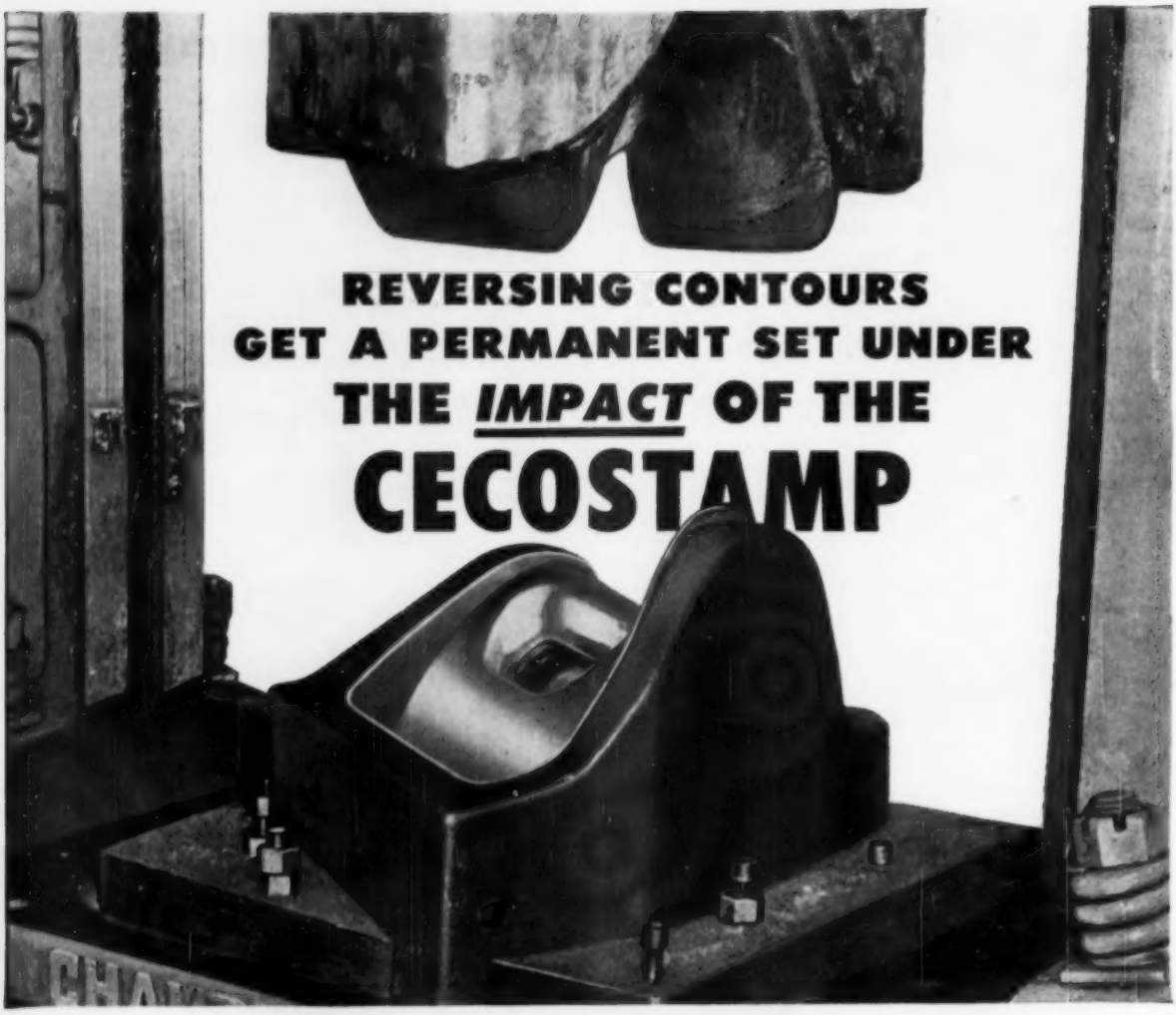
Eventually, TDC hopes to replace conventional, automatically-prepared flight strips with electronic displays employing cathode ray tubes, such as the Convair Charactron or Hughes Typotron.

Display information will cover each flight automatically and when revisions of estimated time over fixes are reported to the controller, corrected flight data will be fed automatically into magnetic storage.

TDC seeks as its ultimate goal in this field the application of "fine grain" position information that is produced by radar, air-ground data links on tele-



FLAME PATHS and characteristics of in-flight fires that can be expected in jet transports are studied to aid in design of fire-detection, extinguishing equipment.



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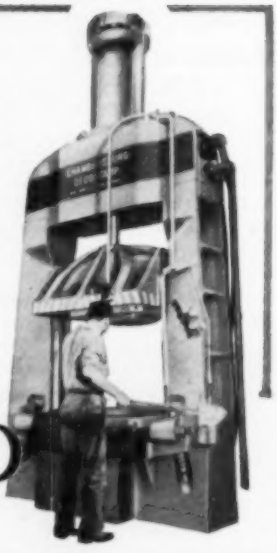
5. *Controlled blow is well suited to forming large integral parts*
6. *Low tooling cost and rapidity of die fabrication*



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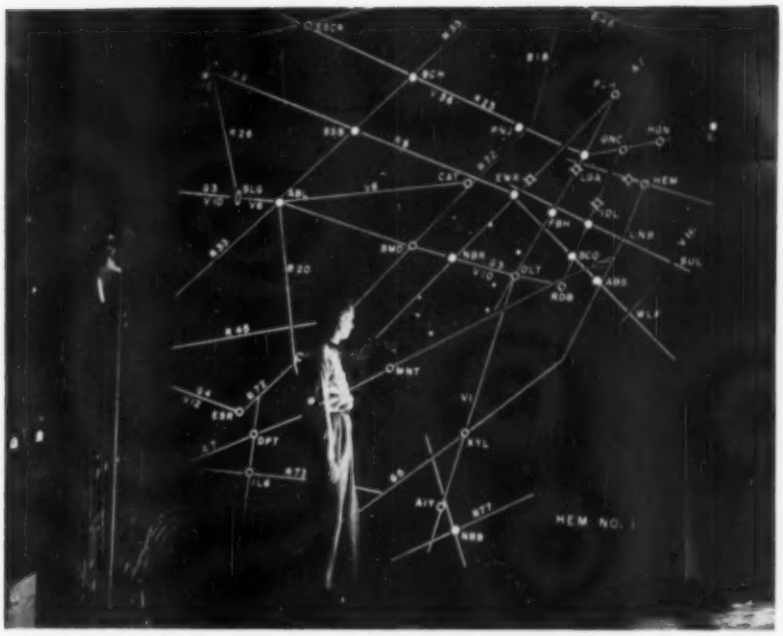


PANORAMIC DISPLAY projected from two traffic control centers is one of several methods used in search for large, bright horizontal display in air traffic control.

metering techniques. This objective will provide controllers with a pictorial display of aircraft positions as well as the electronic flight progress display.

Other advantages will be a reduction in pilot-controller communications and an improvement in airspace utilization through more efficient use of position data.

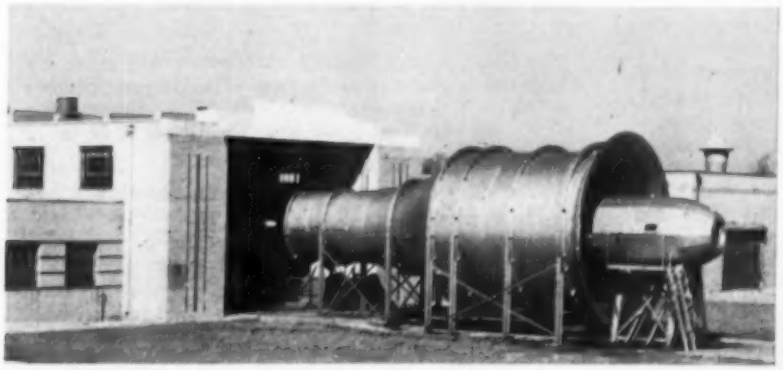
Sometime this year, TDC hopes to begin a full-scale evaluation of the projected program. At the present time, a magnetic drum message storage and processing unit and automatic flight data displays have been developed under a project sponsored by the Air Navigation Development Board.

This equipment has been combined with an automatic teletypewriter switching center for evaluation of the early steps in the over-all program. Up to now, sufficient funds have not been available to include computing features in the magnetic drum storage unit but installation of a computer is scheduled for this fall.

Meanwhile, trained operators have been used to receive flight information, analyze routes, compute estimates and store fix posting messages in the drum for subsequent read-out to the controller displays in simulation of automatic computations.

Development of the air traffic control coordinating equipment has been underway for several years at the Technical Development Center. Actual funds obligated for operation of TDC in Fiscal 1957 totaled $1,156,000. Appropriations requested for Fiscal 1958 amount to $2,821,000. Many of the research and development projects are sponsored by ANDB, USAF, Navy and Army.

For example, technical and opera-



FIRE DETECTION tests on jet engines are run in this 175 mph. wind tunnel, powered by 4,200 hp. motor. Capability is limited to smaller engines for comprehensive testing.

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Nearly one hundred sets of Edo Amphibious Floats are in daily use around the world, piling up proof of their stamina, providing their owners with untold utility.

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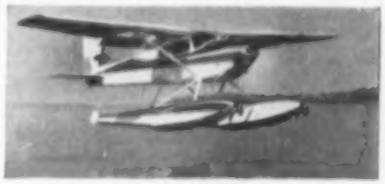

Edo Amphibious Floats are approved for the Cessna 180, the deHavilland Beaver and Otter with only a slight sacrifice in payload and performance—far outweighed by increased utility. Other approvals are pending.

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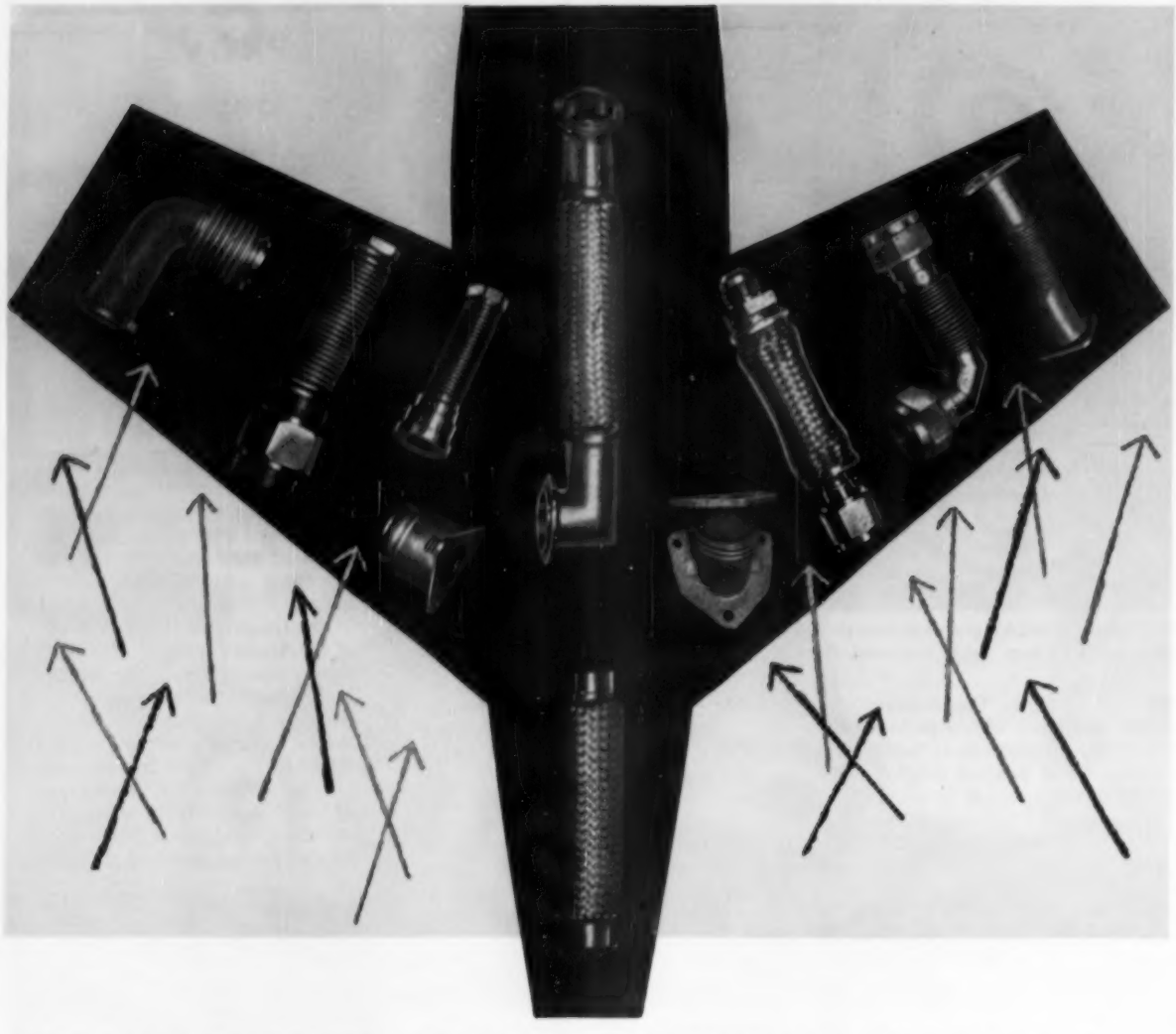

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Circle Number 95 on Reader-Service Card

tional evaluation of the air traffic control radar beacon system is being conducted with ground and airborne equipment furnished under Navy Department contracts sponsored by the ANDB.

Tests on secondary radar system conducted by TDC show that use of defruiting equipment which rejects unsynchronized replies is necessary to prevent deterioration of air traffic control delays. According to D. S. Crippen, chief of the Facility Evaluation Branch, a relatively small amount of fruit can cause serious degradation of displays.

Crippen says tests of a delay-line type of defruiting equipment developed by the Naval Research Laboratory demonstrate that defruiting equipment can be effective. Equipment consists of delayed and undelayed video channels which are connected to a coincidence detector.

Coincidence and video output occurs when video signals having the same pulse repetition frequency of the interrogator are received, according to Crippen.

The center has procured temperature-controlled quartz delay line-assemblies for installation in the ASR-2 radar and the Naval Research Laboratory defruiting equipment to determine feasibility of using temperature control to maintain delay relationship of radar and defruiting equipment lines.

Under this same program, TDC is conducting tests of the Naval Electronics Laboratory radar decoder that writes the code number on an auxiliary indicator called the Matrixatron. Ultimately, TDC wants a decoder that shows a code number next to the target on the display so that both identity and position of aircraft can be read together.

Long-Range Radar Needs

TDC is doing extensive evaluation of long-range radar for airways traffic control. Present need is a display bright enough to be seen under daylight conditions in control towers. The Iatron projection system is being studied as one possible means of producing a picture 16 in. in diameter and of sufficient brightness.

TDC wants a display with good resolution and controllable erasure, and one that is inherently stable and trouble free.

A Panoramic Air Traffic Control Display that projects the radar picture onto a large map-type plotting table also is being studied. RAFAX narrow-band radar remoting equipment and broadband remoting over a link provided by the American Telephone and Telegraph Company also have been given technical and operational tests.

Laboratory tests of all-weather runway lights have been conducted at

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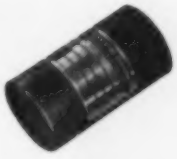

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...even under water

The image orthicon may not be pictured for reasons of security. However, the monitor on which the picture is displayed is commercially available. Designed for the Armed Forces, it is a unit of unsurpassed quality offering superb resolution, extremely good linearity and such unusual features as control of size independent of linearity and the ability to reverse the phase of the signal. Write for detailed description and price.

The human eye is a remarkably sensitive instrument. But it is no match for the image orthicon TV camera developed by Admiral for the Armed Forces. Light from an ordinary match reveals as much to this TV camera as a man with 20/20 vision sees in the light of a 150 watt bulb. Obviously, the armed services will find countless ways to use this sharp-eyed observer for reconnaissance under adverse conditions.

Admiral developed the special circuitry that gives the image orthicon its amazingly keen "eye-sight." For all its extreme sensitivity, there is no penalty in excess bulk or weight.

Admiral has also "packaged" the unit to permit its use not only for land-based and airborne reconnaissance, but *even under water*. Development of the image orthicon again demonstrates Admiral's engineering capabilities in the field of military electronics. Inquiries are invited.

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TDC, and a type of narrow gage Elfaka light buried in the runway and protected by steel grids have been flight tested at Andrews AFB, Md.

The center also is interested in high-intensity fluorescent runway flood lights manufactured by Sylvania Electric Co. These spread a sheet of light over 715 feet of runway to pick up strip markings of luminous paint imbedded with aluminum silicate crystals.

The center is analyzing the effects of flying objects against aircraft through the use of a compressed air gun that will propel the carcass of a chicken up to speeds of 2,000 mph.

Tests are being conducted on the effect of ingestion of birds into turbine engines and on windshields of high-speed jet transport aircraft. Components of the gun consist of a compressor and related equipment that provide an air supply up to a maximum 500 psi., two large tanks for storing air under pressure, a loading breech and a 41-ft. barrel, 6 inches in diameter.

Fire Studies Emphasized

A major research and development project operated by the Technical Development Center involves the study of fire protective and preventative measures in the air. These include development of helicopter crash-fire protection, explosive hazards associated with fuel ingestion in turbine engines, fire detection requirements of the J57 installed in a Boeing 707 pod and an evaluation of the C-130 fire extinguishing system.

TDC is the only place in the United States where wind tunnel tests for fire detection are conducted, although the 175 mph. wind tunnel is inadequate for jet engine tests. Consequently, a compressor-type of blower operated by a 3,500 hp. electric motor has been installed for testing flame paths of a J57. The unit will produce velocities up to 600 mph. to simulate in-flight operations.

TDC also is doing extensive research on mid-air collisions and is conducting a series of surveys to determine leading factors contributing to the collision hazard. High intensity aircraft lights, conspicuity devices, cockpit visibility requirements and proximity sensing mechanisms are being screened in a major effort to eliminate collisions.

Other projects currently under study by TDC:

- **Development of fittings for rupture proof tanks.**
- **Determination of feasibility of helicopter blade bonding.**
- **Tests on load transmission through flexible pavements and base courses.**
- **Development of methods to reduce VOR course scalloping.**
- **Development of directional localizer.**
- **Standardization of receiver, monitor and signal generator.** ■

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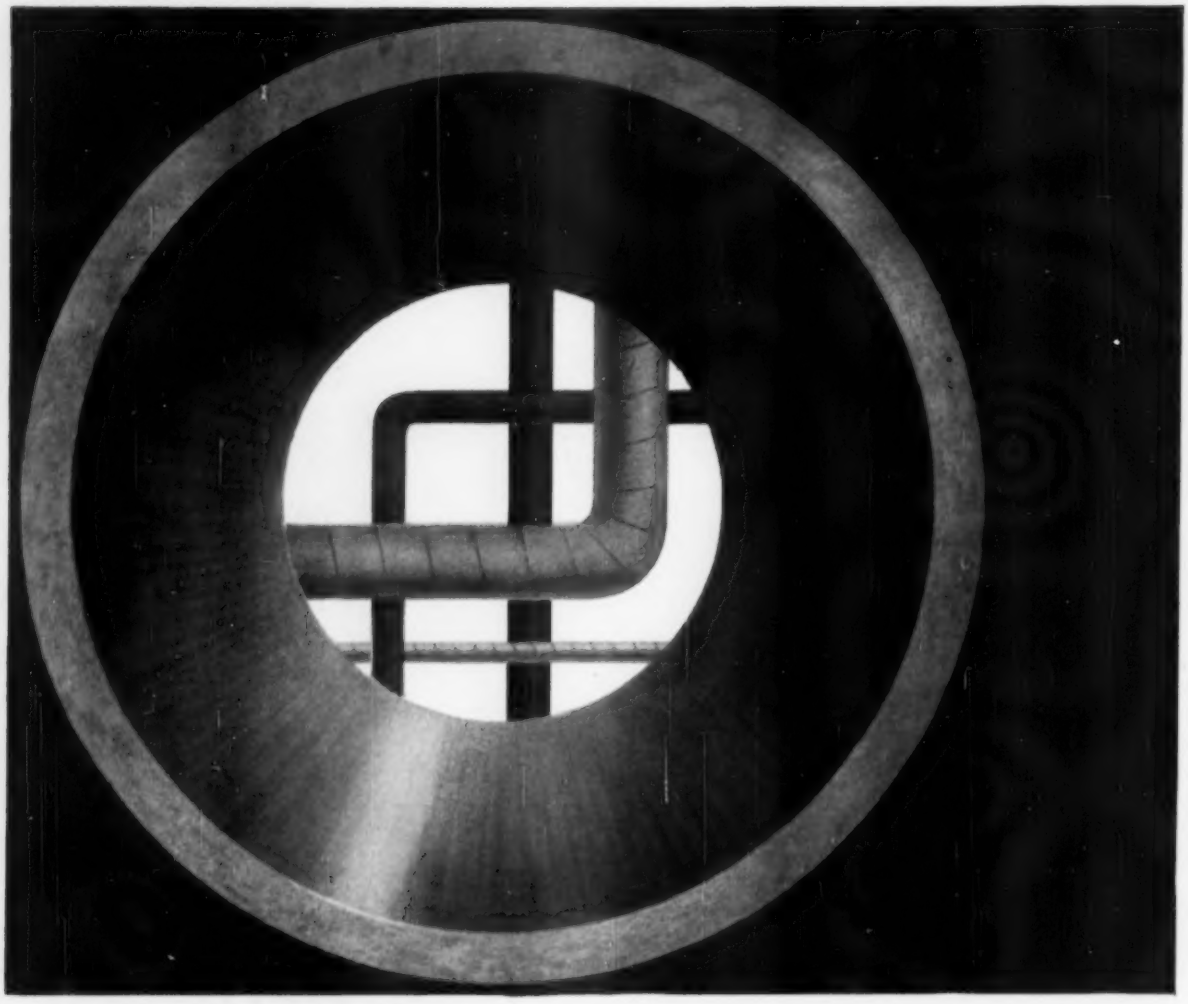

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This is still another in the steadily growing number of products developed with Enjay Butyl Rubber. Contact the Enjay Company for complete information about this truly *wonder* rubber . . . where it can help *you!* Complete laboratory facilities, fully staffed by trained technicians, are at your service.

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Enjay Butyl is the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.

ENJAY *Pioneer in Petrochemicals*

ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N. Y.

Akron • Boston • Chicago • Los Angeles • New Orleans • Tulsa

Circle Number 89 on Reader-Service Card

THE CURTAIN OF FIRE Air protection for whole cities and strategic areas is no longer in the "talking" stage. It is now being installed—a combination of the deadly fire of NIKE anti-aircraft weapon batteries and the U.S. Army Signal Corps' new Martin MISSILE MASTER. As the country's first electronic system designed to provide an integrated screen of radar surveillance, target detection and fire coordination, MISSILE MASTER makes possible peak effectiveness of anti-aircraft missile battery operation. A measure of the critical importance of MISSILE MASTER is the fact that the system already has been designated for a number of our most vital civilian and military areas. It is one of the most significant defense developments of our time.

MARTIN

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NEW

VICKERS

Miniaturized

PISTON TYPE HYDRAULIC PUMPS

3000 psi . . . CONSTANT DISPLACEMENT

These new miniaturized hydraulic pumps were developed by Vickers for limited life applications such as missile and ram air turbine driven hydraulic systems . . . also for motorpump assemblies supplying emergency power on aircraft.

A distinctive feature is adaptability to manifolding and special mounting. This permits integration with the balance of a "packaged" hydraulic system to provide hydraulic power in the most compact and lightweight form yet devised. Some sizes are capable of delivering more than five horsepower per pound of weight.

Available in four size series, this miniaturized pump has the same basic characteristics as the standard Vickers piston type pump which has been establishing outstanding performance records on aircraft since 1940. Ask nearest Vickers Aircraft Application Engineer for further information.

Write for new Bulletin A-5216.

7469

VICKERS INCORPORATED

DIVISION OF SPERRY RAND CORPORATION

AERO HYDRAULICS DIVISION

ADMINISTRATIVE and ENGINEERING CENTER
Department 1462 • Detroit 32, Michigan

El Segundo Division • Engineering, Sales and Service
2160 E. Imperial Highway, El Segundo, California

District Aircraft Sales and Service Offices:

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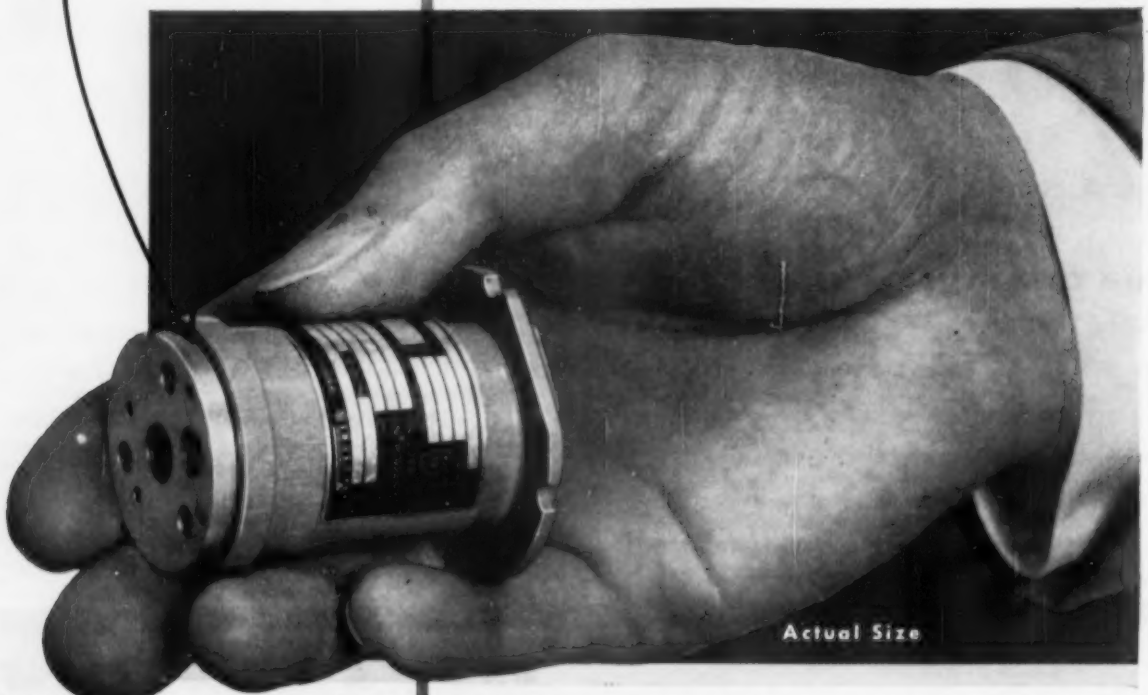
TELEGRAMS: Vickers WUX Detroit • TELETYPE "ROY" 1149

CABLE: Videt

OVERSEAS REPRESENTATIVE: The Sperry Gyroscope Co., Ltd. Great West Road, Brentford, Midds., England

Engineers and Builders of Oil Hydraulic Equipment Since 1921

This Hydraulic Pump has 4.3 hp output @ 3000 psi and 12,000 rpm. Weight 0.9 lb.



A large expansion program now in its early stages means large opportunities for additional engineers at Vickers. Write for information.

Circle Number 87 on Reader-Service Card

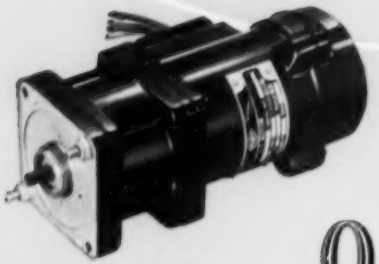
CONVAIR rocket research sled tests rain erosion at Air Force Flight Test Center, Edwards AFB, Calif.

Industry

Because in missiles and jet aircraft everything has to work the first time

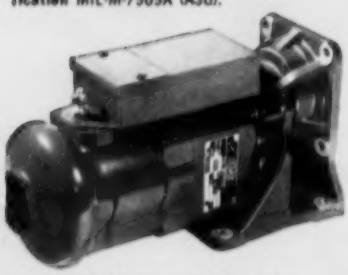
EEMCO AC and DC Motors

have been chosen for use in the majority of our latest aerial weapons.



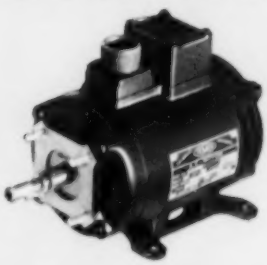
Type: C-1874 400 cycle 3 phase AC Motor and Clutch. **Weight:** 4.5 lbs. **Voltage:** 200 volts. **Output:** 650 watts. **Intermittent duty:** 12,000 rpm. **Meets Military Specification** MIL-M-7969A (ASG).

Type: D-638 400 cycle AC Motor. **Weight:** 17.5 lbs. **Voltage:** 200 AC, 20 amps at 6.5 hp. **Duty cycle:** 3.0 seconds at 6.5 hp, 15.0 seconds at 1.5 hp. **Maximum capacity:** 6.5 hp. **Continuous rating:** 5 hp at 2300 rpm, 15.8 amps, 200 volts. **Meets Military Spec.** MIL-M-7969A (ASG).

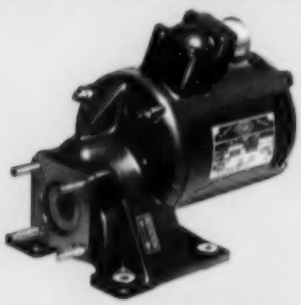


Type: D-751 DC Motor. **Weight:** 20 lbs. **Duty Cycle:** 5.2 hp at 2100 rpm (intermittent) on 26 volts DC; 3.5 hp at 2200 rpm (continuous) on 26 volts DC. **Meets Military Specification** MIL-M-8609.

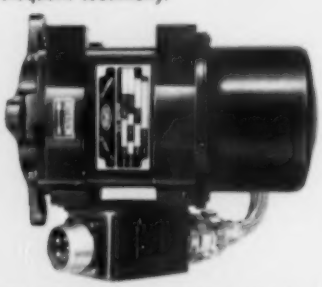
Over the years the precision, ruggedness and reliability of EEMCO products has been proven time and time again. The consistent, exceptional performance of these low-weight, high-output motors, a few of which are illustrated, has earned EEMCO industry-wide recognition. In this highly specialized field, where perfection is imperative, the widespread use of EEMCO motors and of EEMCO's equally reliable actuators is eloquent testimony.



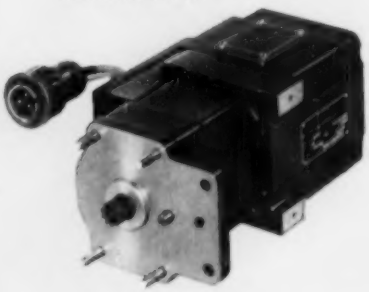
Type: D-800 400 cycle 3 phase AC Motor. **Weight:** 8.75 lbs. **Voltage:** 208 volts. **Horsepower:** 2.5 hp. **Continuous Duty:** 11,300 rpm; Equipped with thermal protector. **Meets Military Specification** MIL-M-7969A (ASG).



Type: D-899 400 cycle 3 phase AC Motor. **Weight:** 11.25 lbs. **Volts:** 200 volts. **Load:** 2.75 hp continuous output. **RPM:** 3140 rpm output at gear box. **Power factor:** 83%. **Overall efficiency:** 76% for entire unit. **Meets Military Specification** MIL-M-7969A (ASG).



Type: D-932 400 cycle DC Motor. **Weight:** With radio noise filter—13 lbs., without same—12.4 lbs. **Terminal voltage:** 27.5 DC plus or minus 1.5 volts. **Load:** From .5 hp minimum to 2.6 hp maximum. **Speed:** Continuous at 12,000 rpm, plus or minus .005%. **Speed Control:** By frequency regulator supplying control field. **Meets Military Spec.** MIL-M-8609 (ASG).



Type: D-927 DC Motor. **Weight:** 7.25 lbs. with 2-circuit noise filter for ungrounded systems. **Weight of filter:** 1 lb. **Terminal voltage:** 27 volts, 18 amps. **Load:** 0.5 hp. **Speed:** Continuous at 9900 rpm. **Meets Military Specification** MIL-8609.

EEMCO ELECTRICAL ENGINEERING & MANUFACTURING CORP.

4612 West Jefferson Boulevard, Los Angeles 16, California—Telephone REpublic 3-0151

DESIGNERS AND PRODUCERS OF MOTORS, LINEAR AND ROTARY ACTUATORS . . . EXCLUSIVELY!

S-850

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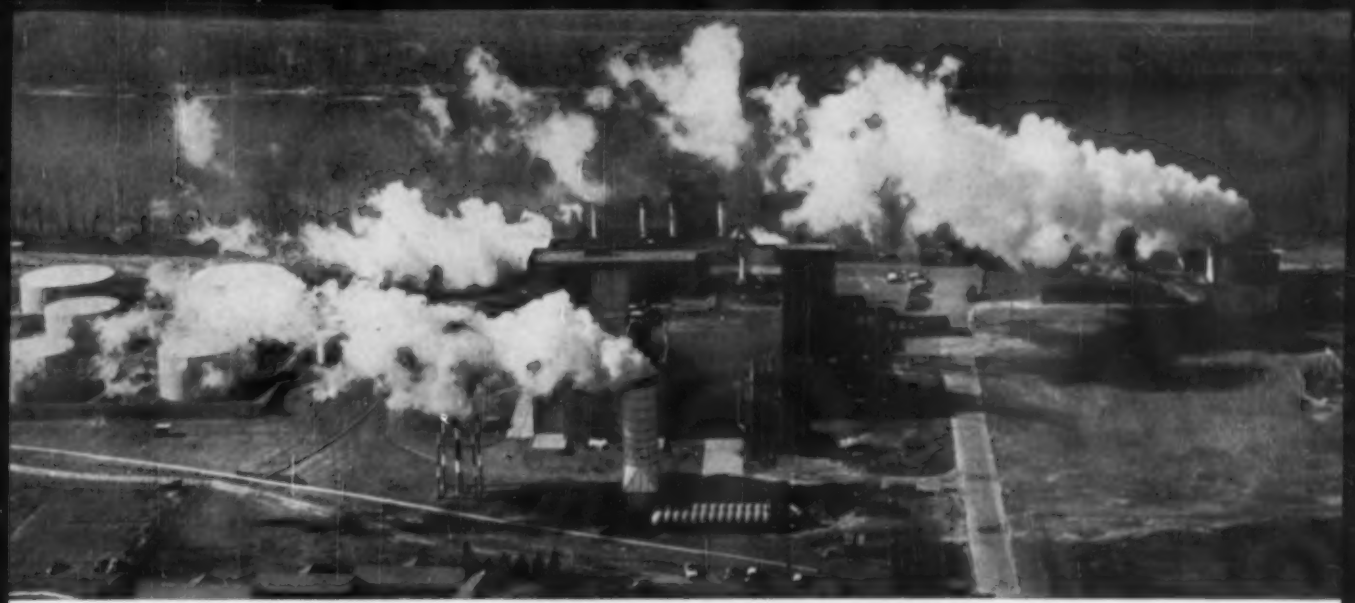

WILLGOOS TURBINE laboratory, with altitude chamber in foreground and sea level test cells at far right.

United Has Proved Value of Research

By J. S. Butz

East Hartford, Conn.—Pratt & Whitney Division of United Aircraft Corp. was conceived, born and lived its corporate life by the principle that an aircraft company must constantly finance and direct an extensive private research and development program if it is to maintain leadership in its field.

Frederick W. Rentschler, P&W's founder, resigned the presidency of the Wright Aeronautical Corp. in 1924 to form a company around that philosophy. Within a year he had secured the financial backing and personnel to form P&W.

The initial engine produced by this small group was a signal success, and P&W has since risen to a position of prominence in the aircraft engine field.

The company feels that this is due in large part to the investment of a sizable percentage of its net earnings toward the continuous improvement of the experimental facilities available to its engineering staff.

These modern facilities, tailored to the task at hand, have allowed P&W development programs to proceed much more rapidly than a program dependent on government, university or cooperative facilities, with their inevitable waiting and limited testing periods.

United Shares Philosophy

An example of Pratt & Whitney's determination to adhere to this development policy was the creation of the Andrew Willgoos Turbine Laboratory in 1950.

This laboratory is the most advanced and extensive privately-owned jet engine test facility ever built.

Initial cost was around $12 million, which was greater than the company's net profit that year.

This unusual expenditure and the constant improvement of the Willgoos facility have been amply justified by the success of the J57 and J75 engines. Production orders for these two engines have helped insure the company's future for a considerable period.

Pratt & Whitney's philosophy has been accepted and continued by United's other corporate members—Hamilton-Standard and Sikorsky Aircraft.

Government Facilities Policy

A basic difference exists between the managements of some aircraft companies and the government as to who should pay for and direct experimental facilities. Current contract renegotiation procedures and other governmental controls generally limit an air

OIL SPRAY pattern on model of wing shows evidence of airflow disturbance.

the world's largest manufacturing facility for aircraft seating
. . . for aircraft interior equipment

*which of these WEBER seats are standard equipment on the Boeing B-52?**

For the part that Weber plays in *today's* B-52's, consult the footnote. However . . . In Weber, there is a *"Department of Tomorrow."* To *build* well—for today's aircraft, is only part of the story.

RESEARCH has brought leadership to Weber. Escape systems are an example: more Weber designed ejection seats are flying today than any other independent firm. And Weber is readying designs for safe ejection systems to meet the ever more critical environments in which tomorrow's flight vehicles will operate.

a World of experience in: Pilot and crew seats, ejection seats, passenger seats, buffets and lavatory units.

WEBER AIRCRAFT CORPORATION
a subsidiary of Weber Showcase and Fixture Company, Inc.
2820 ONTARIO STREET, BURBANK, CALIFORNIA

* 1 Pilot seat; 16 Co-Pilot seat; 6 E.C.M. Operator seat; 20 Tail gunner seat.

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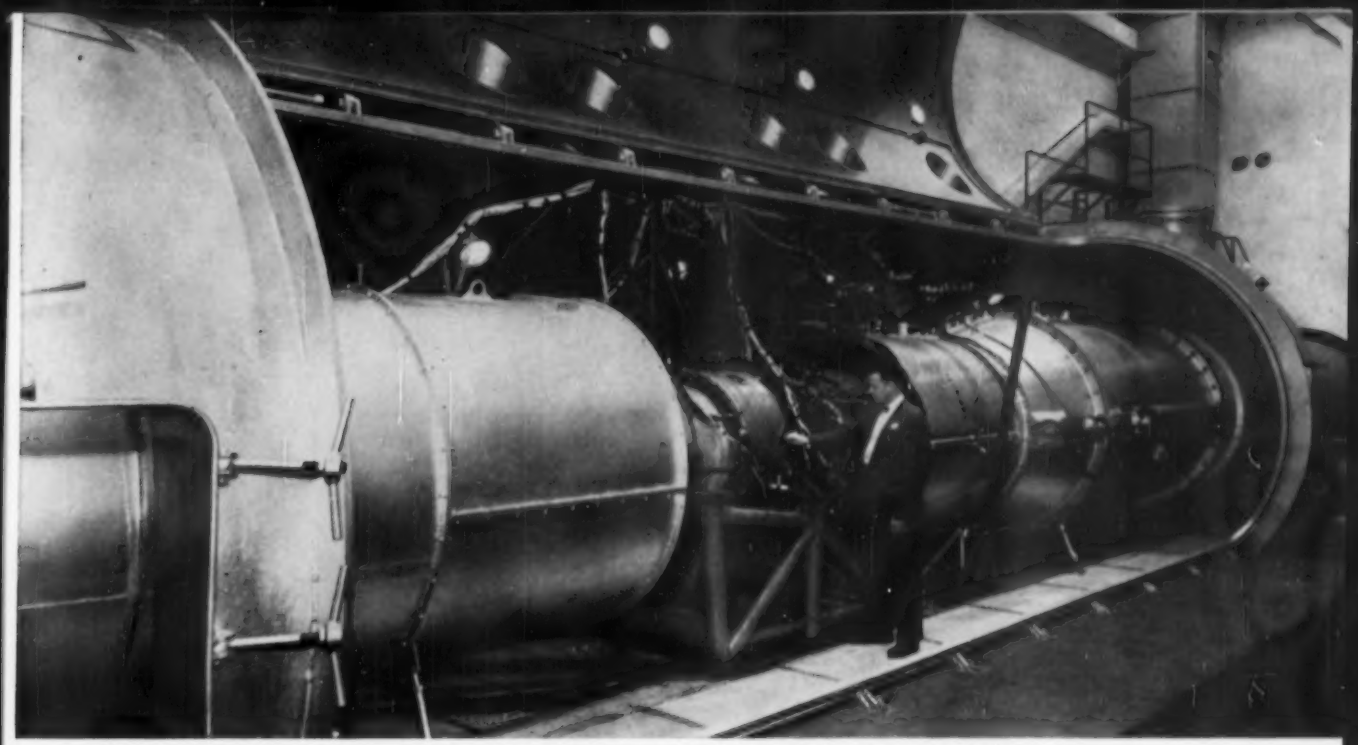


THREE OF 11 Willgoos Laboratory test cells will accommodate complete jet engine for tests at all altitudes.

craft company's net profits to about 5% of total sales or less. Any privately owned and directed test facilities must come out of this net profit.

Many manufacturers feel that their net profits are not great enough to allow any large expenditure and still return a fair dividend to their stockholders and keep suitable cash reserve.

These firms are not leaving themselves without the means to carry out a development program, but they are forced to coordinate their use of outside facilities with other companies.

Numerous as outside facilities are today, a company relying on these alone is limited in many cases to the speed with which work may be accomplished and to the type of results obtained.

The government has built large facilities adjoining many of these companies' plants, but it has retained ownership and in some cases partial management control. In any event, these governmental gifts usually materialize several years after the need for them has become apparent.

Officials at United have stuck with their original conviction that superior private development facilities were vital to their operation, and have continued to build them out of their net profits, regardless of what the profits were.

But P&W joins most other aircraft manufacturers in the belief that more money should be allowed for private development of research and development facilities.

One point in favor of the manufacturers are the generally higher profits realized in most other U. S. industries.

E. I. du Pont de Nemours & Co., Inc., is not typical, but its operation is indicative of what is being accomplished by some firms outside of the aircraft industry. Last year du Pont invested around 5% of its total sales in research and development. Even after this large expense, the company had a net profit of 19.8% of total sales.

Willgoos Laboratory

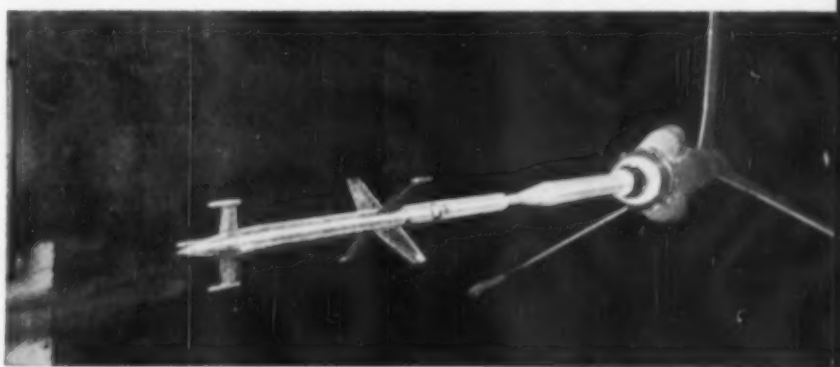
The Andrew Willgoos Turbine Laboratory is Pratt & Whitney's primary development tool. It is constantly being enlarged and improved, and at the present time it comprises eleven large test cells, with a power generating capacity of 80,000 hp. to run the compressors, etc., used in jet engine testing.

The laboratory was first operated seven years ago. Growth since the initial $12 million investment has brought the present worth of the facility to about $40 million.

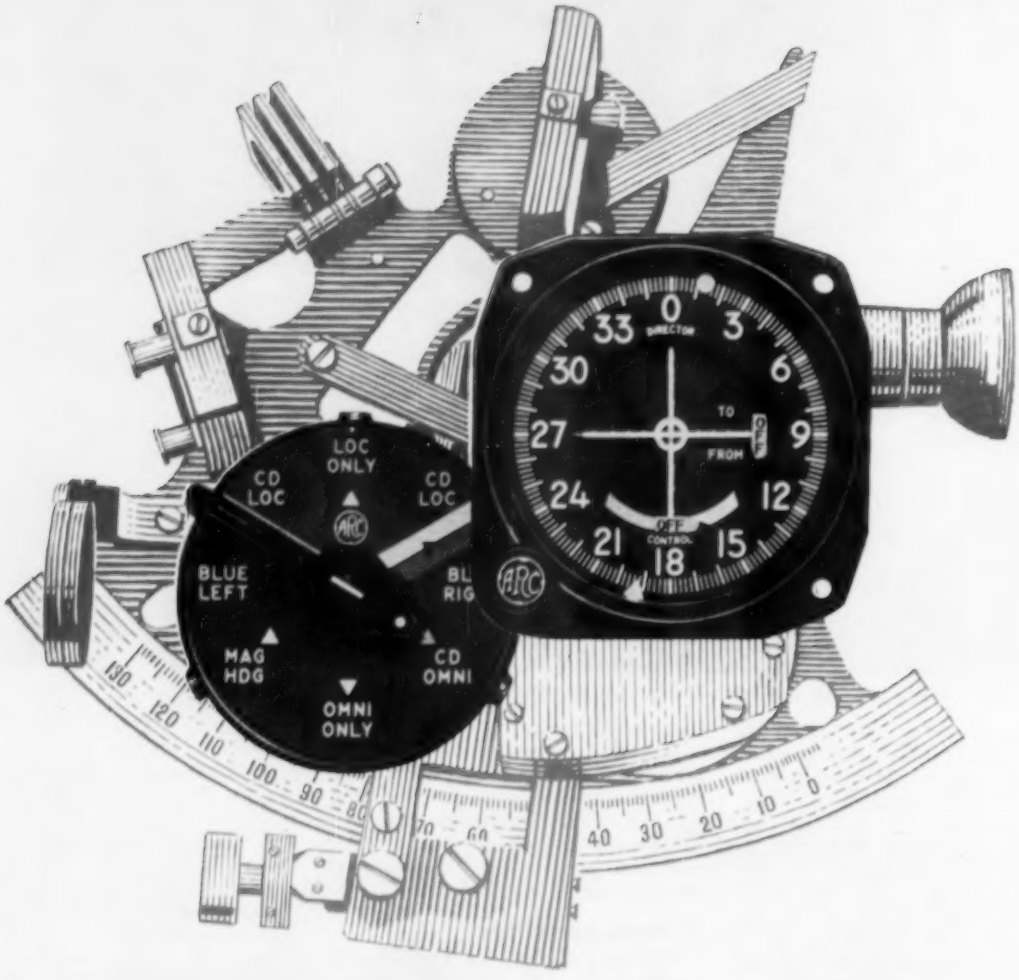
Three of the eleven test cells at the Willgoos Laboratory will accommodate complete jet engines, simulate altitudes to 70,000 ft. and maintain temperatures from −70F to 150F. Engines over 20,000 lb. thrust may be tested over their complete power range at all altitudes.

Another cell is equipped with a 10,000 hp. dynamometer to test propeller-turbine engines, pure jet engines or their turbines alone. This cell also will simulate altitude to 70,000 ft. When the turbines are tested alone, a heavy steel blow-torch like affair is used to simulate the jet engine ahead of the turbine.

Six smaller altitude cells are provided to test burner units and turbine wheels by themselves. Another large altitude cell is used for compressor testing. It is equipped with a 21,500 hp. electric motor to turn large modern axial-flow compressors fast enough to cover their complete operating range. The last two of the eleven cells are for



MISSILE MODEL sting-mounted in 8-ft. tunnel throat.



NEW LOOK in navigation aids

ARC's Course Director CD-1, Teamed with ARC's Dual VOR/ Localizer Receivers 15-D, Shares the Work with the Pilot

More and more pilots rely on the ARC CD-1 Course Director to determine the exact headings required to intercept and fly a desired VOR radial or runway localizer. This electronic "co-pilot" helps them fly with pinpoint precision, greater ease and increased safety, and in four simple steps.

With ARC's CD-1, the pilot selects his VOR or localizer station, sets his Course Director to the bearing of the desired VOR radial or localizer, turns his aircraft until the vertical needle of the cross-pointer meter is centered and steers to keep it centered. His ship will intercept the selected track quickly and smoothly, simultaneously compensating for wind drift. The pilot performs no mental computations, and there's no chance of overshooting the desired course.

This reliable navigational aid adds only 10 pounds to your aircraft. Ask your ARC dealer to install the CD-1, along with a *dual installation* of ARC's Type 15-D VOR/Localizer Equipment. You'll discover how easy flying VOR and Localizers can be – and with new peace of mind.

Dependable Airborne Electronic Equipment Since 1928

Aircraft Radio Corporation BOONTON, NEW JERSEY

Miniaturized Automatic Direction Finders

Omni/Loc Receivers • Course Directors • UHF and VHF Receivers and Transmitters • LF Receivers and Loop Direction Finders • 10-Channel Isolation Amplifiers • 8-Watt Audio Amplifiers • Interphone Amplifiers

Omnirange Signal Generators and Standard Course Checkers • 900-2100 Mc Signal Generators

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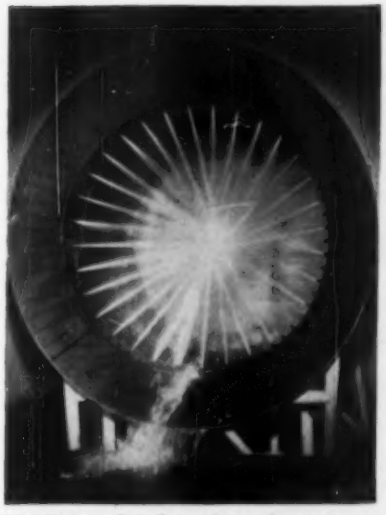


NOZZLE cools exhaust in engine tests.

testing complete engines under sea level conditions.

Pratt & Whitney also has numerous test units which have been partially superseded by the more modern and more powerful Willgoos Lab, but they are still operative and provide much useful data. One is the compressor laboratory, which was built as an interim facility. It could not simulate altitude and was not powerful enough to test large compressors as complete units up to maximum rpm.

Older Test Unit

Another older test unit still in use on a continuous basis is the hot whirl stand for determining the maximum operating conditions for turbine wheels. It is constructed of concrete and steel to retain turbine blades and sections of the wheel when tests end in destruction. A portion of the steel used in the retaining wall is in the form of nested washers which are free to move. This technique allows the washers to roll with the punch and increases their stopping power.

Turbine tests include hot and cold thermal shock runs, in which temperature of the blades is changed by 800 deg. in a matter of seconds; and endurance runs. Work in the hot whirl stand has been greatly expanded as a result of an increase in power that allows testing of larger, multi-stage turbines.

Power generating machinery for the Willgoos Laboratory was provided in a most economical manner. It includes four boilers from Navy cruisers which feed steam into four turbo-generators from war surplus destroyer escorts.

Silencing Engine Tests

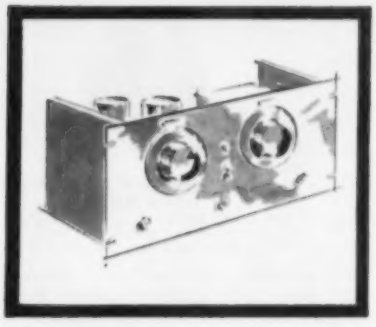
Silencing engines under test was accomplished by:

- **Lowering temperature and velocity of**

Critical operating examination of electronic products and systems under simulated environmental conditions

Trial by Ordeal

Altitude
Vibration
Radio Noise
Salt Spray
Humidity
Shock



Rain
Sand & Dust
Temperature
Acceleration
Sunshine
Explosion
Combined environments

Private industry and government agencies now have access to one of the nation's most modern, instrumented, performance and environmental testing laboratories. Here, electronic equipment is subjected to trial by ordeal, analyzed and evaluated with respect to compliance with performance requirements.

Four distinct laboratory phases are offered, all with automatic programming and/or recording of test schedules: 1/ Formulation of testing techniques, 2/ Qualification and reliability testing, 3/ Environmental testing, 4/ Engineering analysis and product evaluation.

Complete engineering reports are prepared on all phases of the test program. Design change recommendations for equipment improvement are included when requested. Write for illustrated technical folder BJ 58-116.

Reliability You Can Count Upon

BJ *An independent, commercially – available facility of*
ELECTRONICS

Qualified Engineers are assured interesting, rewarding positions with this new BORG-WARNER ELECTRONIC CENTER. Inquire today.

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3300 NEWPORT BLVD., P. O. BOX 1679, SANTA ANA, CALIF.
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AIRCRAFT AND MISSILE CONTROLS

The components shown here are but a small cross-section of the entire range of products we design and manufacture. Many variations of these units have been created to suit specific requirements. A large part of our design effort is also devoted to the development of complete control systems having outstanding performance and reliability.

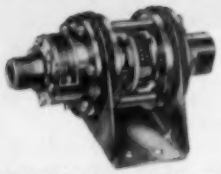
We invite you to discuss your present and future requirements on components or control systems with our engineering staff. Data sheets for current models are available. Please direct your inquiry to our plant at Danbury, Connecticut.

High Temperature (650° F.) PRESSURE SWITCH, Type 6576

CONSTRUCTION: All-welded stainless steel. Precision stacked-capsule sensing element. **TEMPERATURE RANGE:** —65° F. to 650° F. **ADJUSTMENT RANGE:** 20 to 75 psia. **RESET VALUE:** 2 psi. **CONTACTS:** 1 amp inductive snap action. **DIMENSIONS:** Diameter 1¼"; length 3½".

Differential PRESSURE SWITCH, Type 6580

DIFFERENTIAL ADJUSTMENT RANGE: 4" to 125" of water. **SYSTEM PRESSURES:** up to 60 psi. **RESET VALUE:** 1" to 3" of water (proportional to operating point). **EXTERNAL ADJUSTMENTS:** Separate adjustment of operating point and reset value. Alternate style provides two adjustable operating points with fixed reset values.



PRESSURE SWITCH (High Vibration), Type 6885

Integral vibration isolation. External adjustment doubly locked. Small physical size. Airframe, missile, rocket applications. **OPERATING RANGES:** 1 to 800 psi. **SYSTEM PRESSURES:** 5 to 3,000 psi. Available in single and dual assemblies, and in absolute pressure sensing model.

After Burner Fuel Control, Type 141RL37

Schedules afterburner fuel flow as a function of compressor discharge pressure absolute. Unique dual poppet design maintains constant pressure drop across the metering poppet; makes fuel flow a linear function of metering poppet lift. External adjustments permit slope and zero-shift alterations of flow versus compressor discharge pressure curve. **RATED FLOW:** 3,500 to 35,000 lbs/hr.

Dual Hydraulic Pressure Gauge, Type 6966

Dual hydraulic pressure indication within envelope normally occupied by single indicator. **DIAL SIZE:** 1⅞". Instant recognition of system condition—pointers horizontal denote full pressure. No translation. No reading of figures. Safety blow-out disc behind panel.

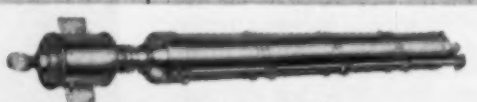
Rotary Torque Booster, Type 141F12

Controls fuel or hydraulic pressure to apply high level output force in response to low level input force. May be inserted in mechanical control linkage to reduce pilot effort. 8 to 1 torque amplification. Simple mechanical design. Poppet operated—not sensitive to dirt clogging. Output shaft will accept 1½° misalignment. Inherently stable.

"VAPOFLASH" Temperature Measuring Probe

A high temperature measuring element intended primarily for gas turbine applications. Provides proportional pneumatic output for 100° F. change in gas temperature. Connection of several units in parallel for averaging permits control of exhaust gas temperatures by variation of exhaust nozzle area, afterburner fuel flow, main engine fuel flow, or other dependent variable. **OPERATING RANGES:** 1,000° to 1,500° F.

Alternate style (Vapoflash Thermal Switch) provides actuation of electrical contacts within the range of 1,000° to 1,500° F.



Pneumatic Exhaust Nozzle Actuator, Type 141F14

Actuators are spaced equally around the tail pipe of a turbojet engine. Use compressor discharge pressure directly to position the exhaust nozzle. Actuator tandem four-piston design provides very high forces within small cross-sectional area. Synchonizing valves act to equalize position of driving points around exhaust nozzle. **EACH ACTUATOR:** 5,000 lbs. force with air at 200 psi. **INLET AIR TEMPERATURE:** 935° F. max. **BORE:** 3". **BARREL LENGTH:** 31.5". **MATERIALS:** Stainless steel, bronze.

MANNING, MAXWELL & MOORE, INC.

AIRCRAFT PRODUCTS DIVISION • DANBURY, CONNECTICUT • INGLEWOOD, CALIFORNIA

OUR AIRCRAFT PRODUCTS INCLUDE: TURBOJET ENGINE TEMPERATURE CONTROL AMPLIFIERS • ELECTRONIC AMPLIFIERS PRESSURE SWITCHES FOR ROCKETS, JET ENGINE AND AIRFRAME APPLICATIONS • PRESSURE GAUGES THERMOCOUPLES • HYDRAULIC VALVES • JET ENGINE AFTERBURNER CONTROL SYSTEMS.

Circle Number 154 on Reader-Service Card

AIR EXCHANGER and turning valves in general purpose subsonic wind tunnel.

the jet exhaust blast by running it through several sheets of water as soon as it leaves the engine.

• **Passing the gas through scrubber tanks** and labyrinths before venting it to the atmosphere.

• **Conditioning intake air** and passing it through labyrinth silencers.

More than $300,000 was spent on the silencing system.

Size of the Willgoos establishment is indicated by these comparisons:

• **An air pumping capacity** of 25,000 hp., more than twice that used to ventilate both the Holland and Midtown tunnels in New York City.

• **Total electrical power output** of more than 18,400 kw.—enough to supply a city of 150,000 with light and power.

• **Water pumping capacity** of more than 160,000 gallons per minute, which is more than six times greater than the normal consumption of Hartford.

Research Department

United Aircraft maintains a Research Department that conducts basic and applied research to supplement the efforts of the three divisions.

Theoretical and experimental research is carried on in the general fields of aerodynamics and propulsion. More specifically, the work embraces subsonic, transonic, and supersonic airflow; combustion, noise, vibration, and associated phenomena; turbine, ramjet, rocket, and nuclear powerplant components; aerodynamic investigations including fixed wing aircraft, missiles, propellers, and helicopters.

Theoretical studies are aided by an exceptionally large and modern computing section which includes five IBM 704 digital computers. Last of these machines is now being installed. The others are in constant use, indicating the volume of work normally undertaken by the Research Department.

Subsonic Wind Tunnel

Experimental equipment available within the department is extensive and varied, but the largest single tool is the general purpose subsonic wind tunnel. It is a closed circuit, closed throat tunnel and is one of the largest in the world.

The tunnel is of concrete construction, and has been in use for more than 10 years. It has interchangeable test sections of 18 feet and 8 feet inscribed throat diameter. Inserts are available to further decrease size of the 8-ft. section and increase the possible test velocities. Maximum testing speeds are about 200 mph. for the largest throat and 700 mph. for the smallest.

Power for the tunnel is provided by an 8,500 hp. synchronous motor through a variable speed, eddy-current clutch. This motor drives a 26-ft. diameter, variable pitch propeller.

The tunnel is provided with large concrete air exchange towers capable of continuously changing 33% of the air passing through the test section. This large air exchange capacity permits close control of the air temperature during testing, and in the case of engine testing, it reduces the concentration of exhaust gas in the tunnel.

Two types of balance systems are available for measuring model forces

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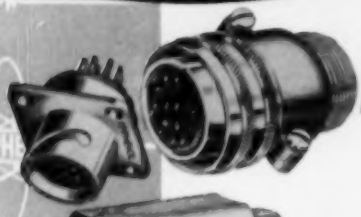
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and moments in the general purpose wind tunnel. One is a mechanical pyramid type balance, which may be used with model support struts mounted on a turntable in the floor or with support trunions at the side wall. The other is an electrical strain-gage balance, which is used with models mounted on a sting support system.

The general purpose wind tunnel is equipped for a wide variety of tests. Constant torque electrical generators of 375 hp. are available for testing propellers, compressors, helicopter rotors, and other rotating parts. These generators are provided with 40 slip-rings allowing 40 channels to be used for strain-gage installations, etc. on the model.

Air supplies, both pressure and vacuum, may be ducted to a model through swivel joints to allow pitching, yawing, etc. This air supply makes possible the testing of boundary-layer control.

Several methods are used by the Research Department to allow visual studies of the airflow about a model. An oil spray is used to coat the model and the airflow etches its patterns in the oil. Tufts are attached to the model or to a screen placed aft of the model.

The screen shows the vortex patterns which trail behind an aircraft. A smoke probe also is used to investigate flow at isolated points on a model. A shadowgraph system also is available for more complete instantaneous visualization.

Other Research Tunnels

Much low speed work is conducted by the Research Department in a pilot wind tunnel. This was built to allow such work to be done at a minimum cost. It has a 6 by 4 ft. test section and a maximum speed of 116 mph. The balance system used with this tunnel is of the pyramid type. All auxiliary equipment and auxiliary power available to the general purpose tunnel are available for the pilot tunnel.

A transonic and a supersonic wind tunnel also are operated by the Research Department. Each has a 17 by 17 in. test section. They are operated from a common 5,000 cu. ft. storage tank, and only one tunnel may be operated at a time. The tank is pressurized by a three-stage reciprocating air compressor rated at 4000 cfm. Maximum pressure obtainable is 400 psi., and 40 min. are required to reach full pressure.

Average duration of a shot is 30 seconds. Average pump-up time is 30 minutes, which also is the average time for a model change. Therefore, it is possible to achieve about two runs per hour with the existing equipment. Each run consists of a full angle of attack range. Angle of attack may be adjusted manually or automatically through a previously adjusted program. When

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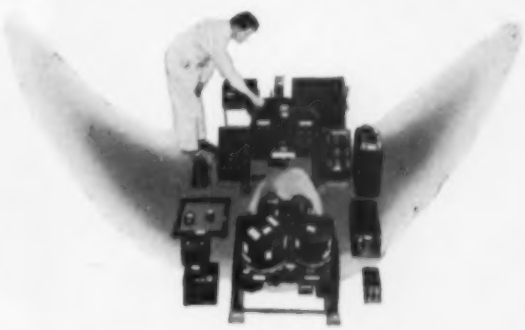

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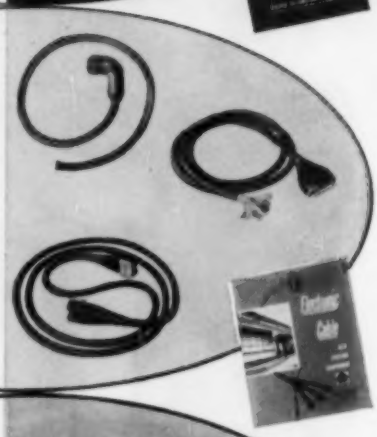
"Design Engineering Specification" Bulletin No. PAP-C-101. Comprehensive 19-page engineering manual describing materials, construction, design criteria, specification conformance, performance, identification, documentation and other important features determining correct cable for your specific application.

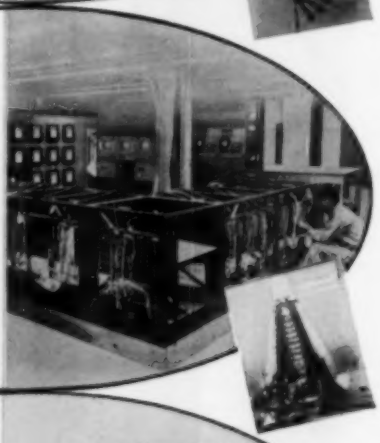
CABLE AS A COMPONENT

"Electronic Cable as a Systems Component" Bulletin No. 656. Generously illustrated pamphlet describes design and production of electronic cable in bulk and assemblies. Connectors and hardware; cable breakouts; environmental requirements; voltage rating, testing; cable procurement data – are some of the subjects covered in this bulletin.



CABLE SYSTEMS

"Engineered Cable Systems" Bulletin 357. Illustrated brochure describing Pacific Automation Products' pioneering in the use of the Systems Concept to coordinate cable design with the development of complex electronic systems. Liaison engineering teams cooperating with systems design groups establish cable as integral part of system, supervising cable construction concurrently with development of other elements.



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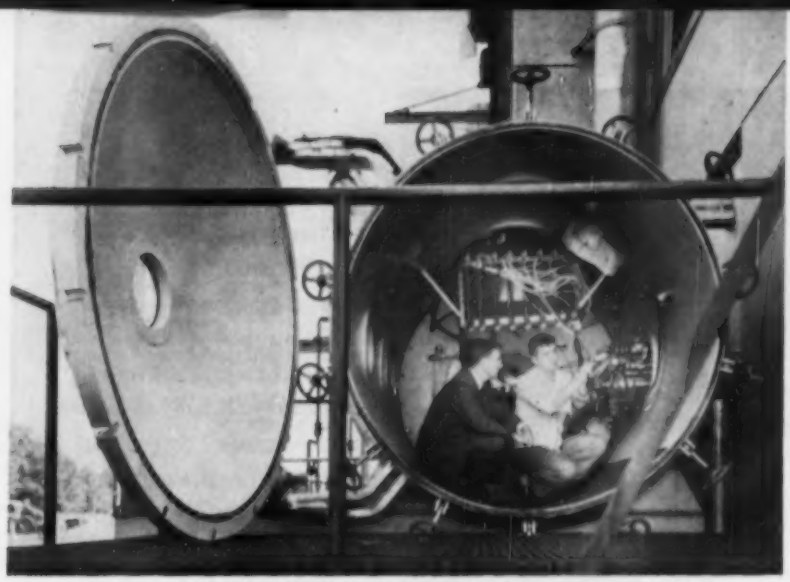


ALTITUDE unit used in work on B-58 air conditioning, pressurization systems.

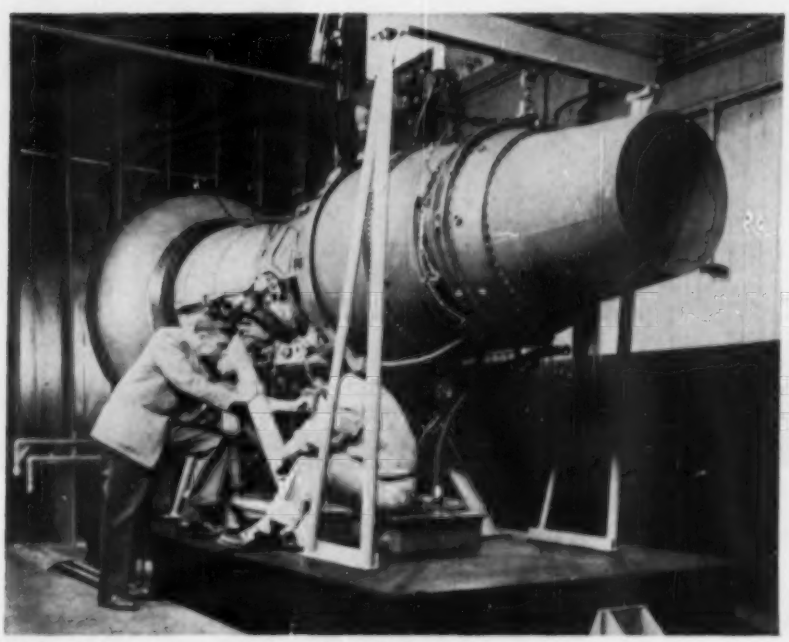
the program is run automatically the range may be covered by a continuous movement or in stages.

The test Mach number is dependent on the ratio between the stagnation pressure and the static pressure. This ratio is maintained during the test run by a cone-type rotary valve, which is controlled by a servo-mechanism. The servo is actuated by pressure sensing elements in the tunnel.

The test Reynold's number could be affected by a large change in pressure due to the expansion on the pressurized air through the tunnel nozzle. This is prevented by a regenerative heat exchanger in the air supply system. Thus the air temperature is prevented from dropping more than 15 degrees from the starting temperature during any run.

Balances used in these tunnels are of the strain-gage type. Pressure measurements may be made on the external surface of a model, in the engine inlet, and of the mass flow through the engine ducts.

The transonic tunnel operates between Mach .8 and 1.5 and is equipped with a perforated throat, surrounded by a plenum chamber. Static pressure maintained in this plenum chamber controls the test Mach number. The perforated walls prevent reflected shock waves from the tunnel sides which would ad-



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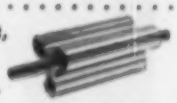

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versely affect any force measurements taken during a test.

The supersonic tunnel has a Mach range from 1.5 to 5.0. It has solid, flexible walls. Contour is maintained by a series of adjustable jacks, and contour determines the test Mach number. To change contour the wall is loosened and the jacks moved to a new position. Then the wall is pulled up against the jacks and held hydraulically.

A hypersonic tunnel is being readied by the Research Department for use in the near future. It will operate between Mach 5 and 10. Test section of this tunnel is in the neighborhood of 6 inches in the vertical plane.

Hamilton-Standard Diversifies

Eight years ago the Hamilton-Standard Division of United Aircraft Corp. began a major diversification program to broaden its line of products, which formerly had consisted of propeller equipment alone.

Today the company is engaged in design and production of jet engine starters and fuel controls, hydraulic pumps, air-conditioning systems, and pneumatic valves, as well as propellers.

Diversification was begun by expanding existing experimental laboratories and constructing new types of facilities to permit complete development of the new products.

These test facilities are among the most modern in the world, due to their recent design and construction. They made it possible for Hamilton-Standard to move to a position among the leaders in the equipment field.

Facilities include laboratories devoted to work in pneumatics, combustion, vibration, fuel control, hydraulics and mechanical test, propellers, and electronics. Full-scale units of all equipment proposed or being produced can be tested over the foreseeable range of operating conditions. Much small test equipment also is provided to check out components of each major item.

• **Pneumatics Laboratory** houses 11 air-conditioning test booths, 6 air-conditioning valve test benches, one bearing test booth, two large walk-in altitude chambers, and the necessary equipment for humidity, sand, dust, salt spray, shock, and acceleration tests.

• **Combustion Laboratory** is located in an explosion-proof building away from the other facilities. It contains 10 test chambers, nine of which are used to develop combustion type jet engine starters, and one for testing fuels above their auto-ignition point.

• **Vibration Laboratory** is equipped for the vibration testing of all Hamilton-Standard products from propellers to air-conditioning units. There are four sound-proof rooms and an air-conditioned stresscoat room for investigating

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This "eye" sees through aluminum forgings to assure aircraft quality

40,000 feet up is no place to discover structural flaws in aircraft forgings. That's why Bridgeport, at its Adrian, Mich., plant, maintains ultrasonic testing facilities, manned by intensively trained and experienced personnel that rank with the best in industry.

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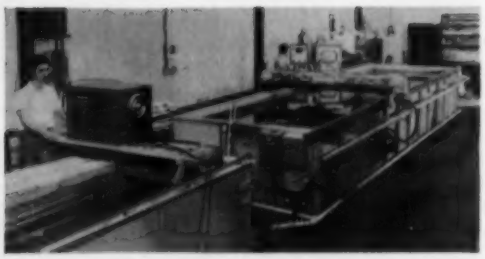

Here's how an ultrasonic scanner head detects hidden flaws in an immersed forging: high-frequency waves see through the forging, send radar-like signal to the cathode ray "eye." If a flaw is present, it is quickly detected and the forging is evaluated.

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stress concentrations during vibration.

• **Fuel Control Laboratory** contains a jet engine test cell accommodating engines (including afterburner) up to 25,000 lbs. thrust for final fuel control tests. It also has 15 benches for calibration and qualification testing of both governed and afterburner type fuel controls. Altitude range is up to 80,000 ft., temperature range is from −70F to 850F, and relative humidity is from 20 to 95%. Fuel temperatures also may be varied from −70F to 250F at a maximum flow rate of 60,000 lb./hr. The laboratory includes an analog computer to simulate the operating characteristics of any jet engine. The computer controls operational and endurance tests of the fuel control systems.

• **Hydraulics and Mechanical Test Laboratory** has four whirl rigs driven by reciprocating engines, each housed in a separate test room. Rooms allow cold, humidity, erosion tests, etc., for propeller hub mechanisms being whirled with weighted stubs to simulate propellers. The remainder of the laboratory has eight separate areas for static structural testing.

Two large propeller test cells are maintained by Hamilton-Standard. They will accommodate reciprocating and gas turbine powerplants up to 20,000 hp. and propeller diameters up to 28 ft. The company also has outdoor facilities for testing greater powers.

• **Electronics Laboratory** contains the usual electronic test equipment plus a shielded room for radio interference studies and an air-conditioned electrical standards room. Three main types of controls being developed are temperature controls for air-cycle and refrigerant types of air-conditioning equipment; fuel controls for gas-turbine engines, and synchronizers for propellers to reduce the noise from multi-propeller installations on large aircraft.

Sikorsky Research Facilities

Research and development facilities of the Sikorsky Aircraft Division of United are tailored primarily for investigations in the three most perplexing fields of helicopter design. These are rotors, power transmissions, and noise, vibration and fatigue.

Much of Sikorsky's research and development work is contracted to UAC's Research Department, with its large wind tunnel and computing section. Sikorsky does maintain four rotor stands, transmission test facilities, and structural and fatigue test equipment at its own plants.

Sikorsky officials feel one of their best research and development investments was the purchase of an S-55 helicopter. This company-owned helicopter allows a rapid flight-test evaluation of experimental projects which have proved satisfactory under ground tests. ■

How would YOU power a weapons pod?

THIS was the problem that faced Convair engineers when they had to find a high energy electrical power source for the B-58 Hustler's detachable pod. It required an entirely new concept in self-contained power.

A representative of Denver's Frank R. Cook Co., Mr. Duncan MacLennan, made a routine call upon Convair to discuss the Cook Co.'s newly developed, highly specialized, automatically-activated batteries. The Convair engineers considered the Cook battery's wide range of power, unusual reliability features and precision manufacture and decided to get the complete story.

On Wednesday, MacLennan mailed detailed specifications to Denver. By Friday the complete Cook Co. proposal was in the mail. When Convair officials reviewed it they saw that all of their requirements, including future design objectives would be met at the outset.

This was in mid-March. Today the electrical power supply for the Hustler's pod is being produced in Denver on schedule.

• • •

This is a typical example of the successful application of a new design concept in high-energy silver zinc batteries. Shipped dry and charged, some designs will furnish full power within 0.1 second upon activation after shelf storage of five years or more. Other features include: hermetic sealing, voltages to 1000 v., current to 1000 amps and MIL SPEC environmental resistance. Prototype lots to your specifications for missile, drone and aircraft reserve electrical power applications are completed in 60 to 90 days with production following rapidly.

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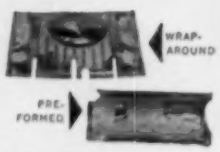

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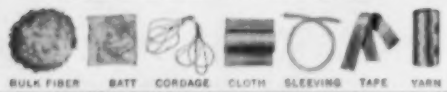

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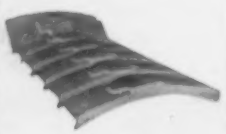

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CONVAIR B-36 airlifts stripped-down B-58 Hustler to Wright Air Development Center for structural tests.

Convair Seeks Lead Through Research

By Russell Hawkes

San Diego—Research minded Convair Division of General Dynamics Corp. is spending its own money to seek competitive advantage in the laboratory. Research and development is conducted at three points in the conception cycle of a new carrier or weapon system.

The three points are:

• **Basic research** that provides the raw knowledge necessary to any further technical advance. Many people have pointed out that the store of raw knowledge built up over centuries is almost exhausted and must be replenished.

Convair spokesmen say they are aware that only a small part of the knowledge gained by basic research may be held as proprietary secrets. The rest of the advantage accruing to the company is less tangible and consists mainly of a shorter time span between laboratory and drawing board, made possible by direct and continuous association between the scientist and the engineer.

• **Development and applied engineering research** that refines the product of basic research for use in a specific piece or class of hardware. This work is done by the divisional engineering departments. It precedes and parallels preliminary design and offers an opportunity for liaison with the fundamental researchers.

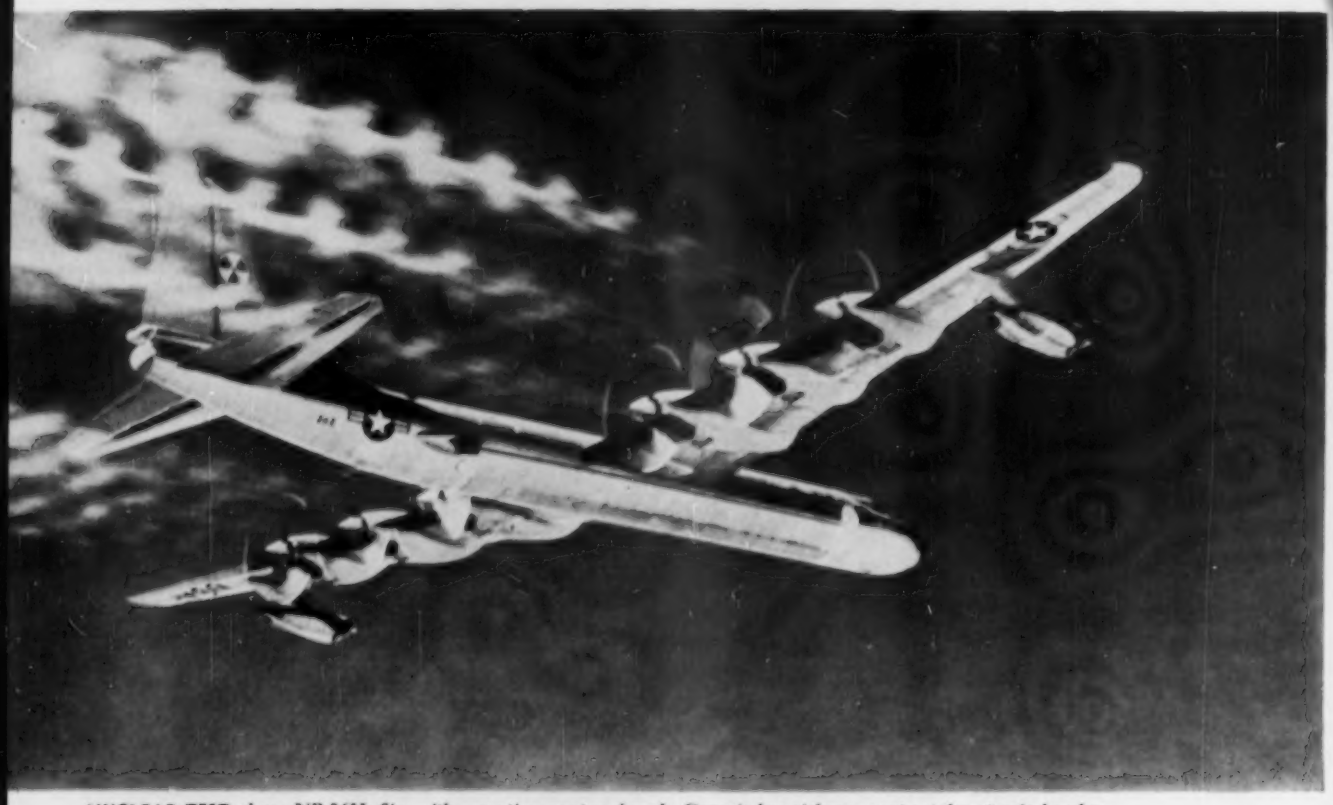
• **Manufacturing research** to provide structural and manufacturing techniques that will enable the shop to build any airplane the engineering department can design. This demands continuous monitoring of the other branches of research for clues about upcoming manufacturing problems.

Scientific Research Laboratory

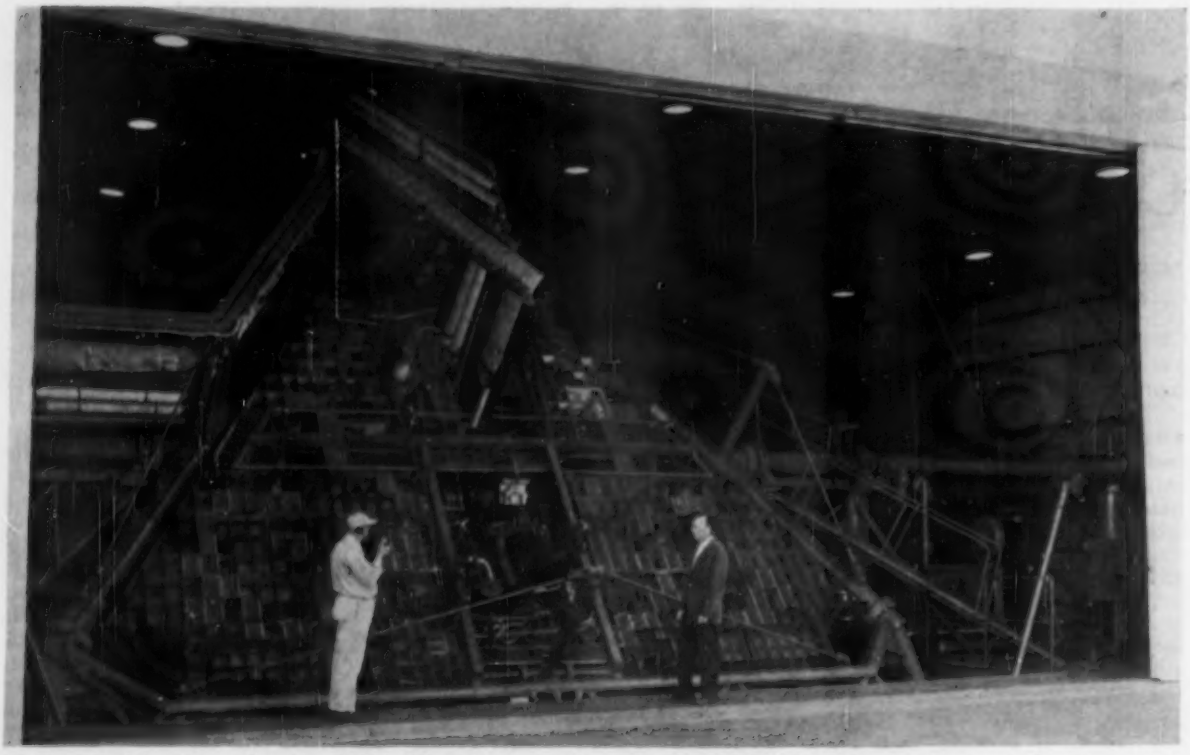
According to Convair budget figures about 40% of the company's research is done by its year-old Scientific Research Laboratory; 50% is done by the divisions, and 10% is done by outside contractors. Basic research at Convair is directed by Dr. Charles L. Critchfield, who is responsible only to the president of the company.

Around the nucleus of his own full time staff in the Scientific Research Laboratory, Dr. Critchfield coordinates contract research and part time research done by people at the Convair local division level. To facilitate the transfer of knowledge to line organizations, scientists spend about 20% of their time in consultation.

The permanent staff is selected to



NUCLEAR TEST plane, NB-36H, flies with operating reactor aboard. Convair has airframe contract for atomic bomber.



SIMULATED delta wing configuration loaded with fuel and gages is put in various attitudes to evaluate fuel systems. Simulator can test full-scale fuel and oil systems of F-106. Facility is at Convair's new fuel laboratory located at San Diego division.

FIRST BOMBER to be developed under weapon system concept was B-58 Hustler, shown here with detachable pod.

provide special competence in gas dynamics, aerodynamics, metallurgy, theoretical and experimental physics, physical chemistry and mathematics. Most are employed in fluid dynamics. Materials researchers are the most difficult to find, and Dr. Critchfield reports that this shortage may produce a crisis in the next year.

How Scientists Are Chosen

Scientists are not hired for specific projects. The scientist-prospect is asked if there is a project he would like to undertake and is hired if it seems likely the project would yield something of value to a manufacturer of aircraft and missiles.

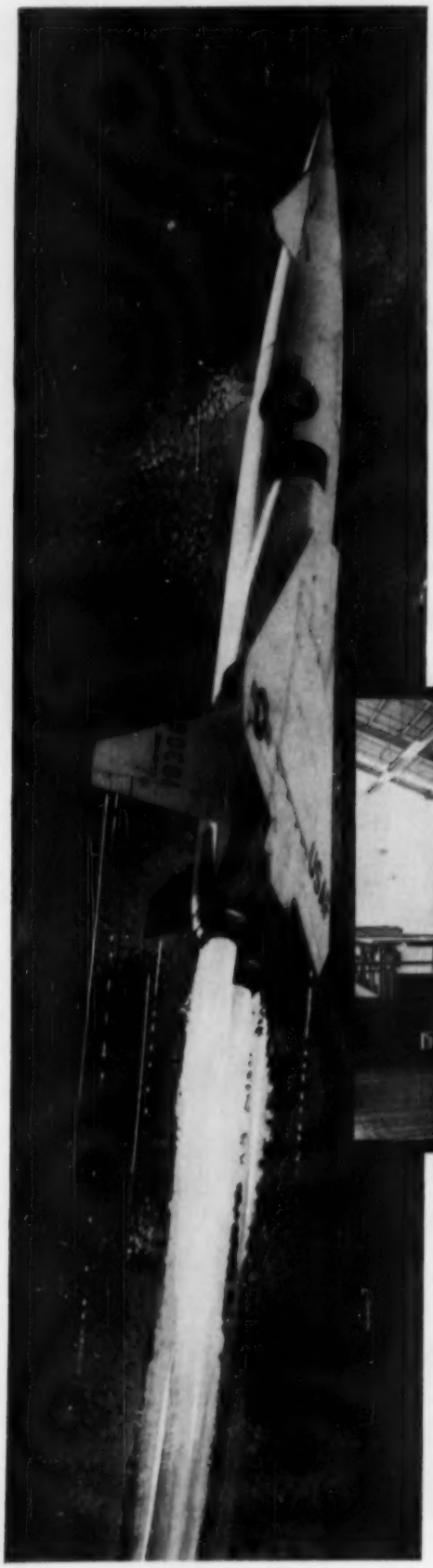
There are now 22 full-time scientists working in the laboratory with the assistance of 13 non-professional and clerical employes. Average age of the senior scientists is 35. About 55% of them hold doctoral degrees and 75% hold masters' degrees.

Because most of the laboratory equipment is breadboarded by the scientists themselves or bought off the shelf, the cost of instrumentation is not high—running about $15,000 per scientist.

The Scientific Research Laboratory now is located in 7,000 sq. ft. of floor space scattered around the San Diego Division. It will move into permanent quarters in the brand new Astronautics Division facility, also in San Diego, sometime this summer. Floor space available in the new quarters will be 25,000 sq. ft.

Management of the Astronautics Division was eager to offer space. Close proximity of the scientists will pay off in development of Atlas ICBM and other Convair missiles operating in

SOUND-ABSORBING qualities of new acoustic chamber are measured by engineers.



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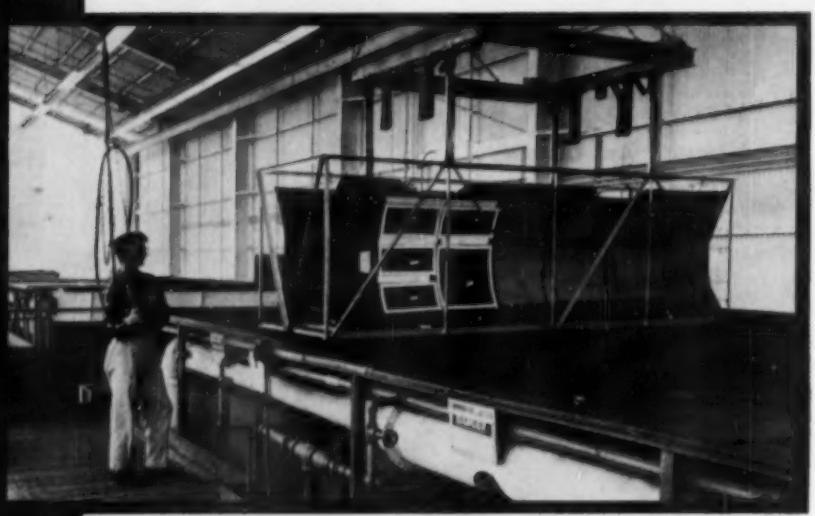
CHEM-MILL process chemically etches stainless steel, titanium and aluminum to accuracies heretofore impossible by conventional milling methods. Provides greater strength with less weight, produces more parts at greater speed, presents new design freedom to engineers.



Designed by the combined engineering efforts of North American Aviation and "Southern", the huge CHEM-MILL plant was completely installed by Southern Engineering Construction Co., Inc.

Southern
ENGINEERING AND CONSTRUCTION CO., INC.

2650 CHERRY AVENUE, LONG BEACH 6, CALIFORNIA
TELEPHONES: GArfield 4-8105 • NEvada 6-3367

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regimes about which little is known. The laboratory will remain independent of any division and will be administered by the company's general offices.

New Laboratory Facilities

Facilities in the new building will include:

- Fluid Dynamics Laboratory.
- Solid State Physics Laboratory.
- Atmospheric Physics Laboratory.
- Instrument Shop.
- Cryogenic Laboratory.
- Mass Spectrometer Facility.
- Spectrophotometer Facility.
- Electronics Laboratory.
- Electronics Shop.
- Materials Laboratory.
- Combustion Laboratory.
- X-ray Diffraction Laboratory.
- Glass Blowing Facility.

Fluid Mechanics Analysis

Among the studies now under way or being prepared is an analysis of the fluid mechanics of mixing layers along a flat-plate surface parallel to the main axis of motion in a high velocity flow. Independent theoretical and experimental projects on this subject will be checked against each other.

In the experimental approach, fluids will be pumped through a porous wall in the 3-in. square test section of a high speed wind tunnel. The porous section probably will be of sintered stainless steel or of densely woven steel mesh. Its results will describe incidentally the mechanics of transpirational cooling.

The $100,000 blow-down tunnel needed for this job is about half funded in the company's 1957 budget. Laboratory spokesmen hope funding will be completed next year. The tunnel will have a two-stage compressor, aftercoolers between the compressor and the storage tanks, and a vacuum system for the tunnel to exhaust into when necessary.

Multiple pump headers will enable the compressor to supply other facilities. The tunnel will be operating up to approximately Mach 2 in early 1958. When the second stage of the compressor is installed capability is expected to rise to Mach 5.8.

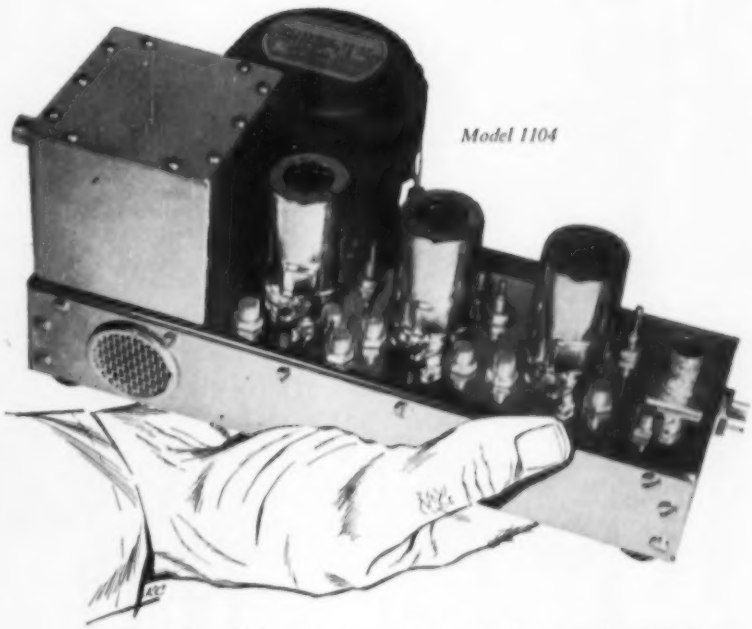
Flame Quenching Studied

Another project is a study of wall quenching of high reactivity flames. Wall quenching is associated with such combustion properties as burning velocity and flash-back boundary velocity gradient. Various fuel-oxidant-inert systems will be used.

Equipment will be a supply tank feeding a conical combustion chamber through its apex. Flame front position in the chamber will be controlled by varying the flow rate of the charge. Conical shape of the chamber permits

SMALL • LIGHT • RELIABLE

high gain preamplifier



Model 1104

Combines high gain with a low noise figure and relatively wide bandwidth. Designed specifically as a telemetering preamplifier to operate over a wide range of environmental conditions. The Model 1104-1 provides a gain of 35 db at band center and the 1104-2 50 db, both with a maximum noise figure of 3.5 db.

Write Box 37, Melbourne, Florida for complete data and prices.

RADIATION INC.

MELBOURNE AND ORLANDO, FLORIDA

ELECTRONICS • AVIONICS • INSTRUMENTATION

Personnel Inquiries Invited.

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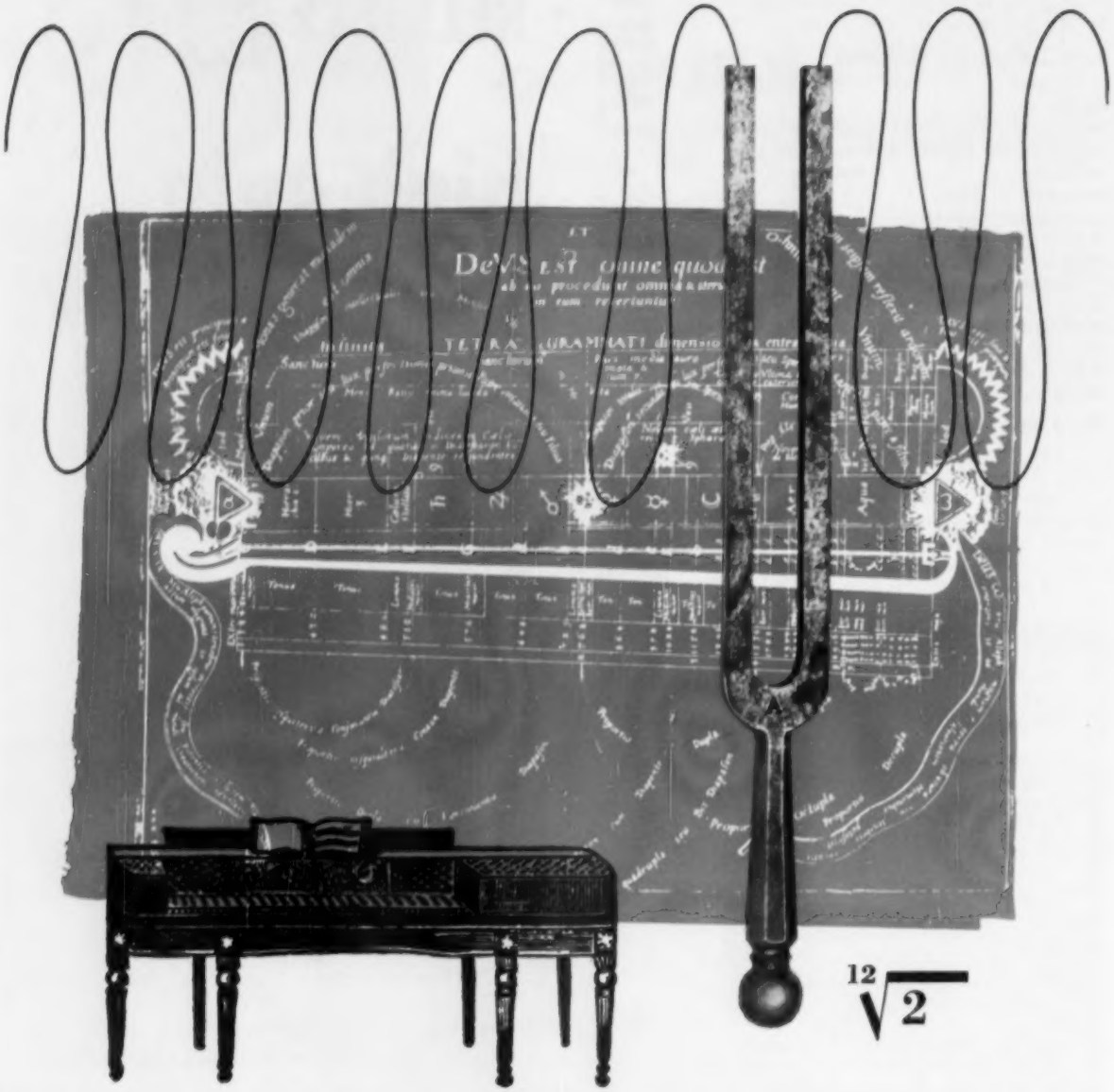

The Formula That Revolutionized Music

MATHEMATICIANS long ago divided an octave into 12 equal semitones, each a successive power of the twelfth root of 2. This "equal temperament" formula was the key to a new world of music that could be created for much-simplified instruments. We like this example of one of the Arts benefiting from one of the Sciences—and of mankind benefiting from both. The example contains the mightiest of the Sciences, a new world of thought, creativeness, and refinement of design. These elements exemplify the work of Litton Industries in advanced electronics.

LITTON INDUSTRIES BEVERLY HILLS, CALIFORNIA

Plants and Laboratories in California, Maryland, Indiana and New York

DIGITAL COMPUTERS & CONTROLS · RADAR & COUNTERMEASURES · INERTIAL GUIDANCE · SPACE SIMULATION RESEARCH
MICROWAVE POWER TUBES · AUTOMATIC DATA PROCESSING · SERVOMECHANISMS · PRECISION COMPONENTS & TRANSFORMERS

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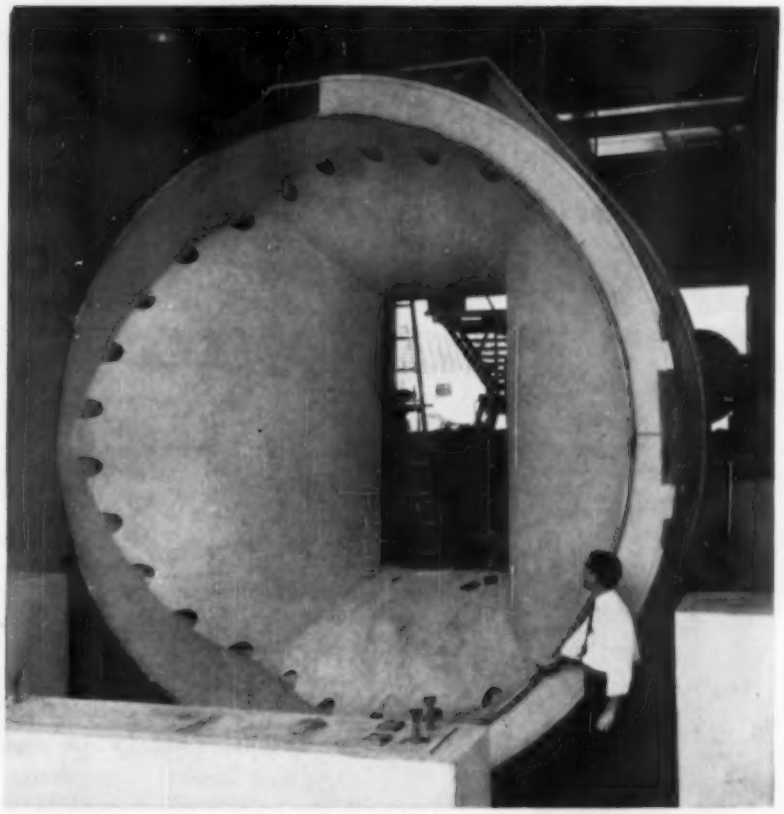


BELL MOUTH of settling chamber in Convair high-speed wind tunnel has 12-ft. diameter.

diameter of the flame front to be varied by positioning it at different points along the length of the chamber.

End product will be a measure of the ability of a flame to propagate through a channel of given shape and size. Laboratory scientists have figured out a theoretical model which they will check against experimental results. Cost of the equipment was $1,000.

Plasma Jet Designed

Several studies of low density ionized boundary layer flow at hypersonic speeds are being made. One is concerned with finding a way to simulate it for further study and possibly to find ways of controlling significant flow parameters. The laboratory now is designing a plasma jet in which noble gases will be accelerated through a 30-in. long Pyrex glass hypersonic nozzle, with a 3-in. diameter test section.

The scientists expect velocities up to Mach 10. Pressure in the test section will be held down to about $\frac{1}{10}$ atmosphere. Gases may be ionized either by an arc in the chamber or by a radio frequency coil around the nozzle which will operate at about 25 mc., and use about 10 kw of power. Cost of the equipment is expected to be about $10,000.

Data taken will include electron density, ion density, energy of electrons, interaction of ions with test models and recombination rate.

Because little is known about ionic wind tunnels, the designers are now running a small arc chamber to gather design information. Helium is being introduced to the chamber through a hollow carbon electrode. The arc leaps to a copper electrode inserted through the nozzle of the chamber.

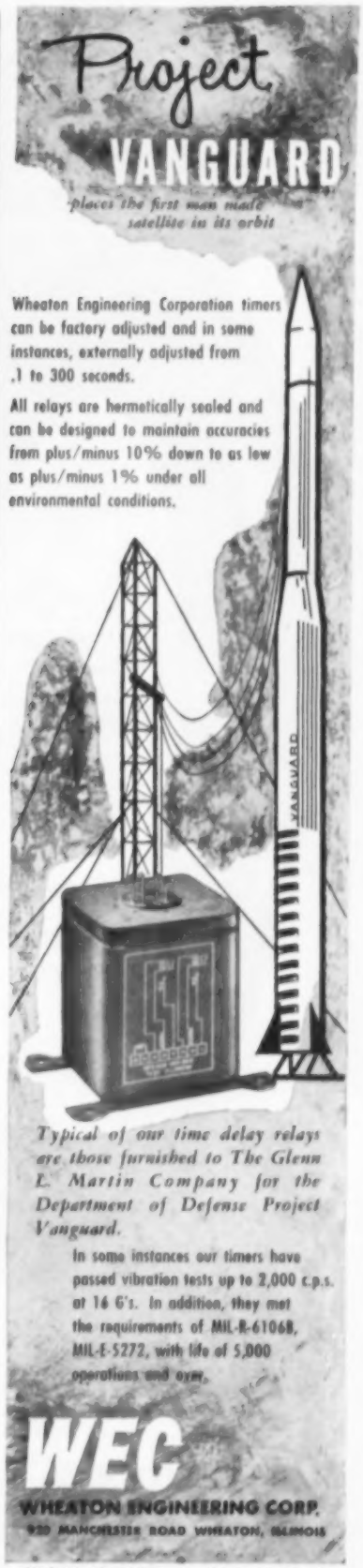
Temperature in the chamber rises to 4,000K and falls to 850K at the exit. Duration of the tests is limited to 30 sec. because the simple model is uncooled. Searchlight generators provide power for the tests. Thermal expansion provides most of the acceleration.

Magnetic Effect on Flow

Another project in this field is entitled "The Effect of a Magnetic Field on Boundary Layer Flow of a Conducting Fluid." It could well result in the devising of techniques to modify the properties of ionized incompressible boundary layer in a way which will reduce aerodynamic heating.

Its purpose is to determine the effect of a normal magnetic field on incompressible flat-plate boundary layer skin friction and laminar boundary layer stability, and to gain basic understanding of the magnetic interaction with the velocity field for boundary layer flow.

Locally non-adiabatic flows will be


Project
VANGUARD
places the first man made satellite in its orbit
Wheaton Engineering Corporation timers can be factory adjusted and in some instances, externally adjusted from .1 to 300 seconds.
All relays are hermetically sealed and can be designed to maintain accuracies from plus/minus 10% down to as low as plus/minus 1% under all environmental conditions.
VANGUARD
Typical of our time delay relays are those furnished to The Glenn L. Martin Company for the Department of Defense Project Vanguard.
In some instances our timers have passed vibration tests up to 2,000 c.p.s. at 16 G's. In addition, they met the requirements of MIL-R-6106B, MIL-E-5272, with life of 5,000 operations and over.
WEC
WHEATON ENGINEERING CORP.
920 MANCHESTER ROAD WHEATON, ILLINOIS
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FACTS

about

NEW DEPARTURE BALL BEARINGS

PERFORMANCE PROVED... IN THE AIR!

New records are continually being piled up by America's many types of ultra-fast, high flying jet aircraft. And these records provide strong testimony as to the reliability of the vitally important bearings used — New Departure ball bearings such as the turbine mainshaft bearings developed through New Departure's extensive Aircraft Bearing Research Program.

And looking ahead to the even more powerful and faster aircraft yet to fly, New Departure is developing ball bearings to help make their flight success complete.

Split ring mainshaft bearing has high thrust capacity. Stabilized for high temperature operation.

Send for bearing catalog ABC

BALL BEARINGS MAKE GOOD PRODUCTS BETTER

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONN.

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studied using a vortex tube and a resonating tube, costing $18,000. Scientists hope the resonating tube will yield information on the non-adiabatic exchange of energy between fluid elements. Questions are:

• **What mechanism generates heat** in an insulated flow of compressible viscous fluid?

• **What is the coupling** between stream intensity and the amplitude and frequency of oscillation?

Resonating tube is ¼-in. in diameter and its length is variable from zero to 12 inches. A small rocket blasts gases into the open end of the tube to produce oscillations. Velocity of the jet now is subsonic and Mach number is not considered an important parameter, but preparations are being made for a Mach 4 jet resonating tube.

Hot wire anemometers and microphone transducers will be used to measure velocity and pressure distributions within the tube. Among the useful information which this investigation may produce are better understanding of turbojet noise generation and perhaps a clue to the mechanics of combustion instability in rocket motors.

Upper Air Research Planned

Awaiting CAA approval is an upper atmosphere research program using mylar balloons similar to Skyhook. CAA clearance is necessary to avoid creating a traffic hazard when the balloons are launched from their site at Fallbrook in San Diego County. Equipment for the program is all purchased and ready to go.

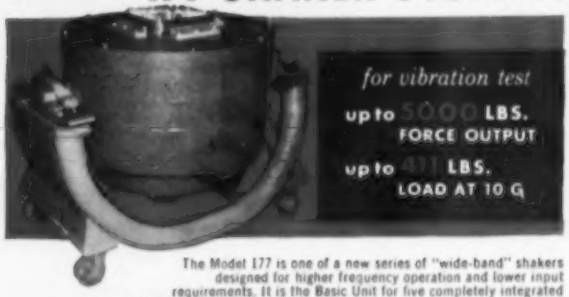
The quarter-mil thick mylar balloon will hold a million cubic feet of helium at its maximum ceiling of 140,000 ft. It is lighter and stronger than the polyethylene Skyhook, weighing only 215 lb.

The 50-lb. payload will telemeter information on ion density, free electron density, cosmic dust density and size distribution, temperature and pressure gradients, cosmic radiation and solar radiation in the ultra-violet part of the spectrum.

The balloon will remain aloft for four-hour periods and will be tracked by Rawin. Laboratory scientists expect 95% recoveries of the balloon and its instrument package. Convair is the only civilian organization ready to attempt this type of research with its own money.

To increase the volume and diversity of basic research and to improve liaison between the Scientific Research Laboratory and the manufacturing divisions, Convair has an arrangement by which anyone in the company can submit to Dr. Critchfield's office a request for sponsorship of specific research projects. Many of these are contributing useful

NEW CALIDYNE 177 SHAKER SYSTEMS



The Model 177 is one of a new series of "wide-band" shakers designed for higher frequency operation and lower input requirements. It is the Basic Unit for five completely integrated CALIDYNE Vibration Test Systems. Oscillatory linear forces up to 5000 lbs. are generated and precisely controlled over wide ranges for vibration research and test of products up to 411 lbs. maximum load. Any of these five Vibration Test Systems using this New Model CALIDYNE 177 Shaker will enable you to:

1. Discover effects of "brute force" shaking on your assemblies and determine their ability to withstand vibrations far beyond those of normal operation.
2. Provide factual vibration data essential in determining mode shape, frequency and damping characteristics.
3. Determine results of fatigue testing at extremely high stresses and deflections.

CALIDYNE VIBRATION TEST SYSTEMS USING NEW MODEL 177 SHAKER

System Number	Type of Vibration	Force Output	Power Supply	Frequency Range	Maximum Load 10 g.	Maximum Load 20 g.
1	177/80 Sinusoidal	3500 lbs.	Electronic	5-2500 cps.	361 lbs.	86 lbs.
2	177/180 Sinusoidal	5000 lbs.	Rotary	5-2000 cps.	411 lbs.	161 lbs.
3	177/186 Sinusoidal	5000 lbs.	Electronic	5-2500 cps.	411 lbs.	161 lbs.
4	177/190 Random or Sinusoidal†	5000 lbs.	Electronic	5-2500 cps.	411 lbs.	161 lbs.
5	177/190 Random†	5000 lbs.	Electronic	5-2500 cps.	411 lbs.	161 lbs.

† *This system will perform with Random, Sinusoidal, Tape or Mixed Inputs.*

A separate Bulletin 17700 details the specifications, performance data, basic components and accessories of the new Model 177 CALIDYNE Shaker and its five Shaker Systems. For engineering counsel in applying Controlled Vibration to your research and testing, call us here at CALIDYNE — Winchester (Boston) 6-3810.

THE CALIDYNE COMPANY
120 CROSS STREET, WINCHESTER, MASSACHUSETTS
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TROUBLE-SHOOTER'S FRIEND *

*DOT Wire Harness Bands

Wires can be removed or replaced one-handed, without removing DOT Wire harness band. Spring tension prevents accidental opening. Resilient, moisture-proof lining insulates wires, cushions them against chafing. Lining will not pull loose. Made in seven standard sizes from 3/16" diameter to 2".

Available with swivel, rivet, snap-fastener or snap-on clip mountings.

MONADNOCK MILLS San Leandro California
Subsidiary of UNITED-CARR FASTENER CORP.
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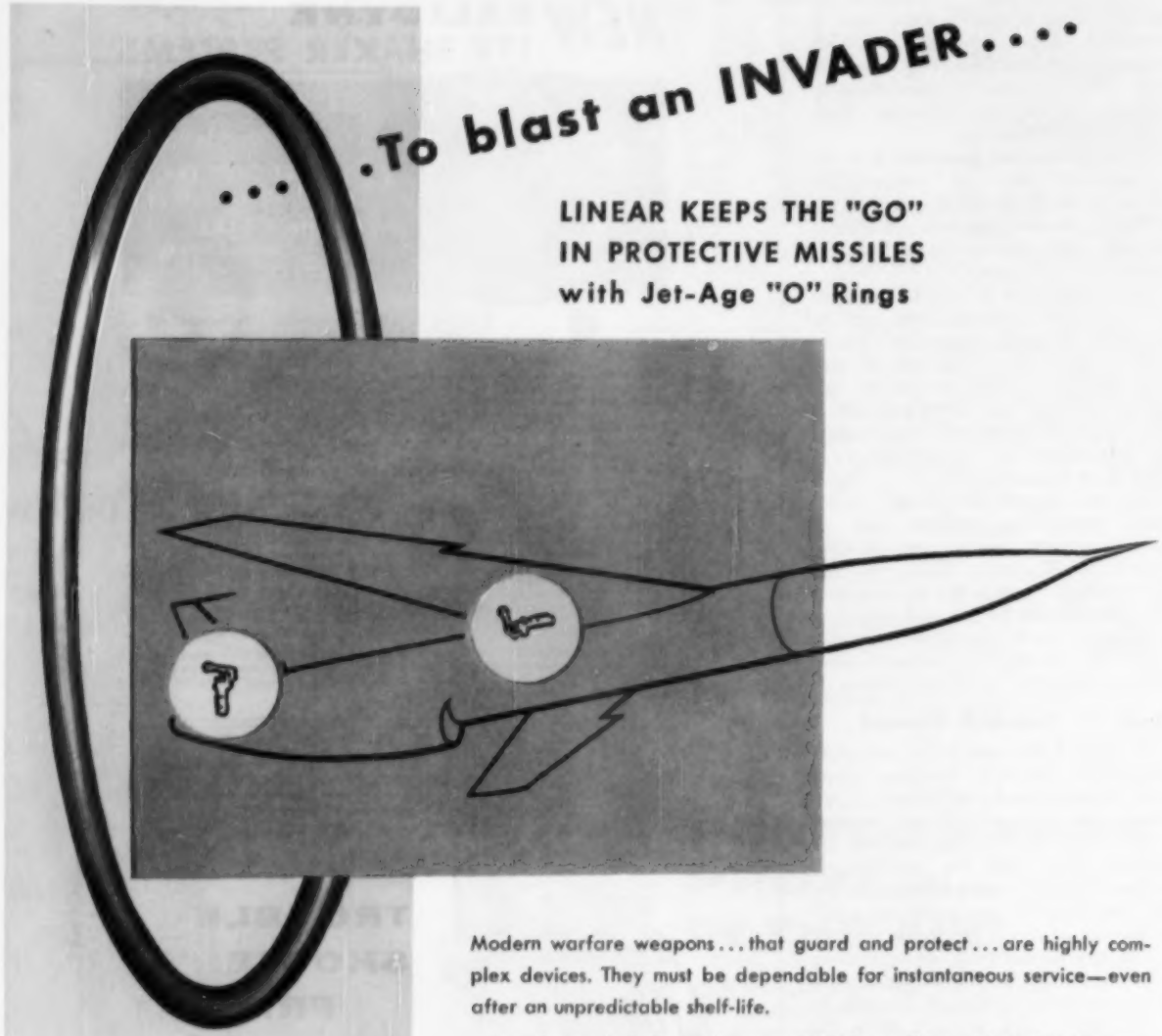
. . . To blast an INVADER . . . .

LINEAR KEEPS THE "GO" IN PROTECTIVE MISSILES with Jet-Age "O" Rings



Modern warfare weapons . . . that guard and protect . . . are highly complex devices. They must be dependable for instantaneous service—even after an unpredictable shelf-life.

In rocket and missile warfare use, "O" rings will be subjected to nitrogen, JP-4, ethylene oxide, hydrogen-peroxide, alcohol, liquid oxygen, fuming sulfuric acid, and other destructive environments. "O" rings are used in the servo-systems for flight control of guided missiles, and must withstand extremes in temperatures and the destructive actions of synthetic fluids.

LINEAR'S experience in the design and production of precision "O" rings —of the most modern elastomers—has given them the ability to provide dependable seals for the most critical requirements.

When it's a sealing problem, call on LINEAR or one of its agents for engineering assistance . . .

and be sure to specify LINEAR "O" Rings for prototype or production.

"PERFECTION IN RUBBER"

LINEAR

LINEAR, Inc., STATE ROAD & LEVICK ST., PHILA. 35, PA.

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information to the laboratory's own projects.

Convair's advanced study programs are loosely monitored by a consultant board of more than a dozen top-ranking scientists in all of the fields of interest. Dr. Critchfield himself is an alumnus of this group.

Since the members are always heavily engaged in other activities and are for the most part individualists, Dr. Critchfield's staff cannot hope for a nicely formalized operation. So far it has proved impossible to get over half the board together in one place at the same time. Usually the consultants are called individually for advice or criticism of specific projects.

Recently, Dr. Critchfield has been trying to get them to spend a few days or weeks at a time in San Diego living with the problems. The ability of the consultants has enabled them to point out bad approaches and recommend better ones on the basis of cursory examinations of the work of staff scientists and part time researchers in the manufacturing divisions.

If more leisurely examinations were possible, Dr. Critchfield feels they would be able to hasten progress even more by analyzing in detail theoretical models and experimental techniques being used. Presently, 15 days a year is about the largest amount of time any consultant has been able to spare the company.

Division Research Breakdown

According to the budget breakdown, about 90% of division level research is done by engineering departments and 10% is done by manufacturing people. Applied engineering research requires more extensive facilities than does basic research since often it deals with full-scale aircraft and missiles. Larger and more costly facilities also are more practical, since the problems to be solved and the techniques to be used already have been formulated by basic research.

Where a common need exists the expensive facilities are built and operated under an inter-divisional arrangement and the most conveniently located division handles administration. Management decides whether to duplicate equipment in the divisions after comparing the value of meeting slightly different requirements and the cost of the duplication. Another consideration is the anticipated scheduling load.

Present laboratory area may double in the next five years according to Convair officials.

Mach 5 Blowdown Tunnel

Most of the expensive interdivisional facilities are located on the seaplane ramp of the San Diego Division. A new $3.5 million Mach 5 blowdown wind tunnel with a 4-ft. test section is

LEWIS
Selector Switches

FOR RESISTANCE THERMOMETERS
AND THERMOCOUPLE THERMOMETERS

EACH SWITCH HAS "OFF" POSITION PLUS NUMBER OF POINTS LISTED.

Points	Size	Switch Part Numbers Thermocouple Type	*3 Wire Resistance-Thermometer Type
2	2"	11S2	36SR2
3	2"	11S3	36SR3
4	2"	11S4	36SR4
5	3"	10S5	37SR5
6	3"	10S6	37SR6
8	3"	10S8	37SR8
9	3"	10S9	37SR9
10	3"	10S10	37SR10
12	3"	10S12	37SR12
16	3"	10S16	37SR16
18	3"	10S18	37SR18
20	3"	10S20	37SR20
24	4"	27S24B2	38SR24
28	4"	27S28B4	38SR28
40	4"	38S2C	

*Resistance thermometer switches are provided with a safety resistor on off position.

2" SIZE

3" SIZE

SPECIAL SWITCHES

No. 37S6C2, Four "4 Point and OFF" thermocouple switches combined in one 3" case.

No. 9S5, Single Pole, Four Point Instrument Switch in 1¼" round case.

No. 44S4, Six Pole, Double-throw Instrument Switch in 2½" round case, one hole mounting, ½-32 threaded bushing.

4" SIZE

DESIGNED FOR TEST WORK AS WELL AS FOR PERMANENT INSTALLATIONS. LEWIS SELECTOR SWITCHES ARE CONSTRUCTED WITH STURDY CONTACTS OF LOW RESISTANCE AND POSITIVE DETENT. THESE SWITCHES ARE SPLASHPROOF, DUSTPROOF AND ARE BUILT TO GIVE YEARS OF SERVICE.

THE LEWIS ENGINEERING CO.
NAUGATUCK, CONNECTICUT
Manufacturers of Complete Temperature Measuring Systems for Aircraft

Circle Number 148 on Reader-Service Card

HULL MODEL in new 300-ft. towing tank, which also accommodates ballistics tests.

being built there and should be ready for calibration by September.

The engineering research staff at San Diego hopes to begin making actual runs around the first of the year. The tunnel will be supplied by six tanks capable of storing 28,000 cubic ft. of air at a pressure of 600 psi. Nominal duration will be 20-30 seconds to read out 40 data points.

Starting cycle requires 4½ seconds at maximum pressure to blow the normal shock down to the diffuser throat before the valve position is programmed down to the correct position for the planned Mach.

The after-cooler for the 8,000 hp. compressors will draw water from adjacent San Diego Bay through a gravel filter on the bottom. The insulated storage tanks will contain half-inch balls of tabular alumina to absorb the remaining heat generated by compression and release it again when the tunnel is fired to compensate for expansion cooling as the air issues through the supersonic nozzle.

Configuration of the nozzle will be varied to limit angularity of flow by adjusting the shape and position of flexible stainless steel top and bottom walls with 56 screw jacks positioned along the 38-ft. length. A half turn of each jack wheel causes only .0005-in. adjustment in the position of the flex plate at the jack point. The variable downstream diffuser for supersonic operation can be replaced by a perforated wall section to permit unchoked transonic operation.

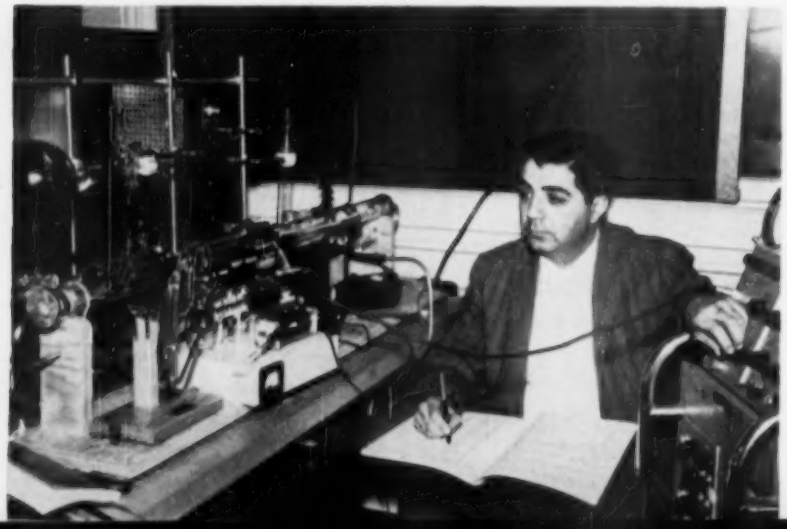
Tow Tank Operation

Convair still is interested in the high performance seaplane, typified by the Sea Dart experimental water-borne fighter.

One facility now operating at San Diego is the 300-ft. tow tank for hydrodynamic testing of hull shapes.

In the four months it has been in use, models have been driven down the tank at speeds as high as 75 mph. For a 1/22 scale model, this is the equivalent of 250 mph. A wavemaker at the end of the tank can produce the equivalent of 10-ft. seas. Present equipment cost $300,000. The divisional engineering departments hope to get

FREE RADICAL experiment by Dr. H. A. Papazian is done in search of high-energy fuels.



Aeroquip
Engineering Notes

B. A. MAIN, JR.

As the advertisement says, we believe there is no mystery to making a good hose of Teflon. However, while there may be no mysteries involved, this shouldn't be construed to mean that the process is simple or that no controls need to be imposed.

The spotlessly clean room mentioned we have found necessary to prevent foreign inclusions. Even a wing or leg of an insect or lint or other such foreign particles can and have resulted in flaws in a finished hose. We, in engineering, feel that we are lucky that Aeroquip's color is red. This color is light enough so that inspectors can easily spot any such particles in the tube extrusion. And, every inch of our tubing is carefully inspected before it is braided.

We use the standard duPont No. 6 Teflon powder. It is interesting to note that it is shipped in small containers. If several of the powder grains should stick together these then will produce a flaw in the extrusion. To avoid this, the use of small containers is one precaution so that weight of the powder in the container will not be enough to cause the powder grain at the bottom to be compressed too much.

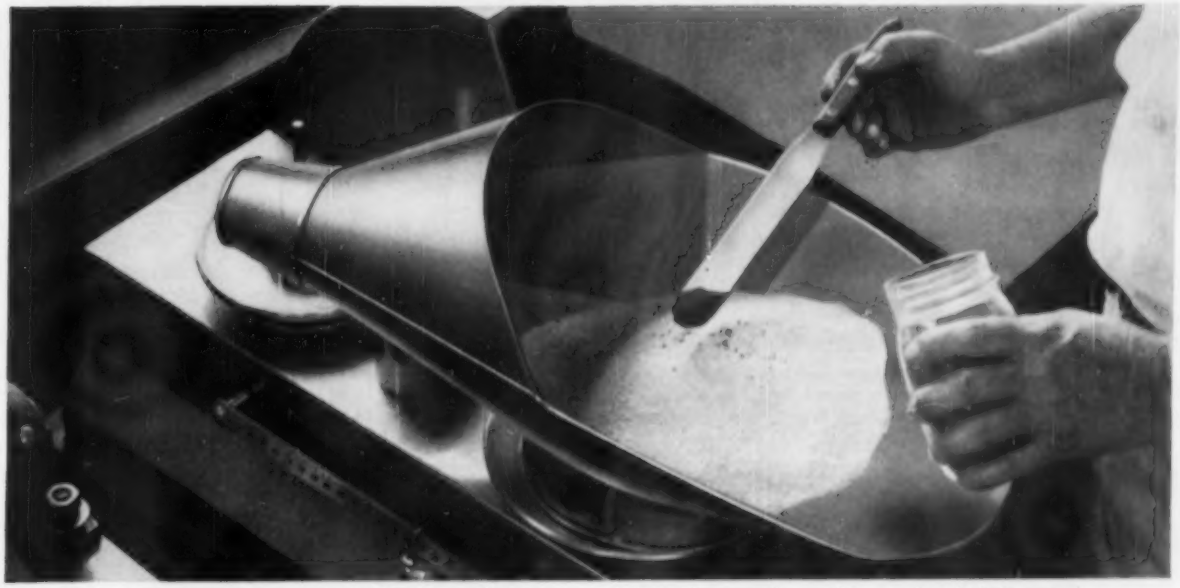
Without getting into all of the details, let me say that the per cent of crystallinity in the Teflon extrusion is important to performance of this hose. The controlled temperature and humidity of the entire process area, we feel, is very important in controlling crystallinity percentage, and our constant checks of our production show that we do control it very closely.

Braiding the Teflon tubing is more important than might be thought at first glance. Because the transverse strength of the extrusion is somewhat lower than the longitudinal strength, we have found it desirable to braid the tubing down appreciably. In other words, we extrude the tubing larger in diameter than the intruded finished size and then braid it down. We do this on horizontal braiders, because we can control the tension, the pitch of the braid angle and the diameter very closely. This gives us uniform diameters inside and out, and close control of elongation or contraction of the finished hose.

Naturally these advertisements are directed at influencing the readers to buy Aeroquip Hose Lines with their Detachable, Reusable Fittings. We feel that the more precision we can build into the hose and fittings, the easier it will be for the users to put them together anytime, anywhere. The close dimensional control we get from use of the horizontal braiders helps insure this. We also get close control of elongation or contraction of the hose when it is under pressure and we feel this goes a long way towards insuring uniform performance in applications where the hose is subjected to rapidly fluctuating pressures.

B. A. Main Jr.

VICE PRESIDENT, ENGINEERING
AEROQUIP CORPORATION



(1) Imagine a room kept spotlessly clean . . . where temperature and humidity never vary . . . where the air is filtered, and workers are provided with special lint-free clothing. These are the conditions under which the manufacture of Aeroquip 666 Hose starts, with a mixture of exact amounts of sifted Teflon powder, lubricant and coloring.

There's No Mystery to Making Hose of Teflon*

. . . the Only Secrets Are the Methods Used to Guard the Uniformly High Quality of Aeroquip 666 Hose (Teflon)

(2) After proper aging, the mixture is formed into a "cake" which is fed into an extrusion press and emerges as tubing. Wall thickness, diameter and concentricity are carefully controlled. The tube of Teflon passes through electric ovens (pictured above) where it is sintered and assumes the characteristic "Aeroquip red" color.

*DuPont Tradename for its Tetrafluoroethylene Resin

(3) After inspection, the tube moves to the braiding machine where it is reinforced with stainless steel wire. The closely controlled method used results in exceptionally tight, positive braiding . . . a distinctive Aeroquip feature. After passing final tests, the hose is identified as "Aeroquip 666", your assurance of unequalled quality in hose lines made of Teflon.

"super gem" is an Aeroquip Trademark

Especially designed for Aeroquip 666 Hose is the Aeroquip **"super gem"** Fitting which is leakproof, can be attached quickly with hand tools, and reused many times. Get complete information today.

Aeroquip Corporation
Jackson, Michigan

Gentlemen:

Please send me your Bulletin AE8-13 on reusable **"super gem"** Fittings and 666 Hose of Teflon.

Name_____

Title_____

Company_____

Address_____

City_____ Zone____ State_____

Aeroquip

REG. TRADEMARK

AEROQUIP CORPORATION, JACKSON, MICHIGAN
AEROQUIP CORPORATION, WESTERN DIVISION, BURBANK, CALIFORNIA
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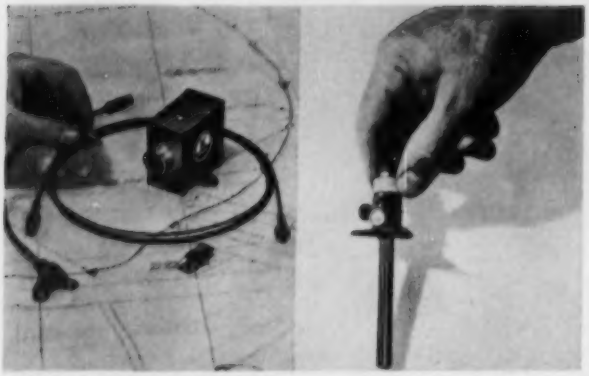
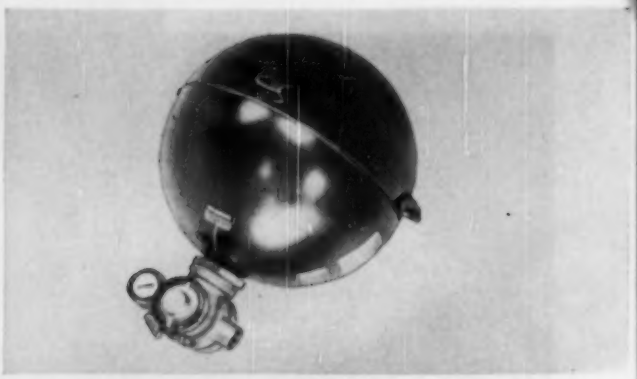
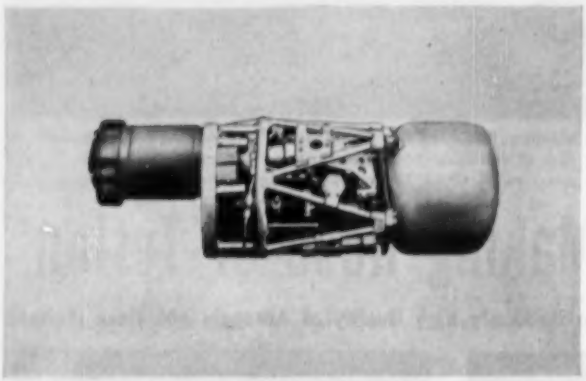


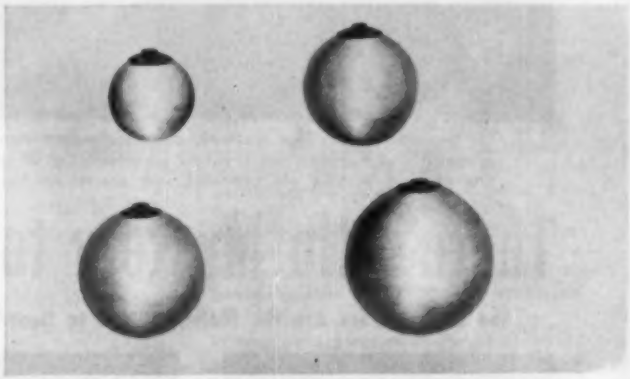
HEAT-FIRE DETECTION Zone type (left) for all-over detection. Gives an overheat danger signal and fire alarm. No tubes, no resetting after a fire. Spot type (right) for specific locations—set from minus 65 to plus 1000 degrees F.



PUSH-BUTTON FIRE EXTINGUISHING SYSTEM Uses CF_3BR, CF_2BR_2, CB, MB, or CO_2... pressurized in spheres of strong, lightweight steel. System manually operated by pilot. Discharges in a fraction of a second.



AUXILIARY POWER SYSTEMS Lightweight, monofuel systems for guided missiles, piloted aircraft. Turbine driven with horsepower of up to 200; supplies regulated power at mean altitudes of 40,000 feet and more.



FIBERGLASS SHATTERPROOF AIR-STORAGE SPHERES Pressurized air containers—strong enough to handle pressures up to 5,000 psi, yet 40% lighter than steel. Available in volumes of from 50 to 5,000 cubic inches.

FOR AIRCRAFT: EXTRA SAFETY, EXTRA POWER WITH PRECISION PRODUCTS BY KIDDE!

Leaders in the aircraft safety, auxiliary power and pneumatic system fields, Kidde now offers a wide range of precision products combining the advantages of light weight with dependable operation. More than 95% of the aviation fire extinguishing systems installed on U. S. planes are Kidde-built. Kidde's auxiliary power systems are finding wide use on both guided missiles and high performance aircraft. And Kidde air compressors and pneumatic power systems are used by Boeing, Fairchild, Lockheed, North American, Republic, Douglas, Convair, Avro. If you have a safety, pneumatic or secondary power problem, Kidde's advanced engineering staff will develop, test and manufacture equipment to meet your exact specifications. Call or write Kidde today.

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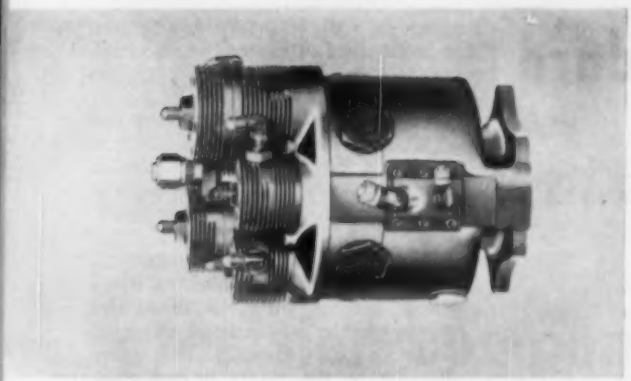
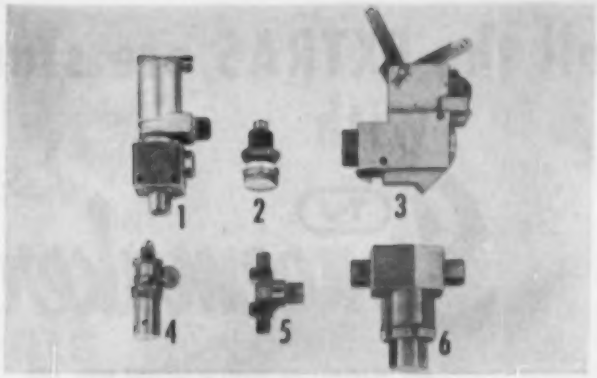
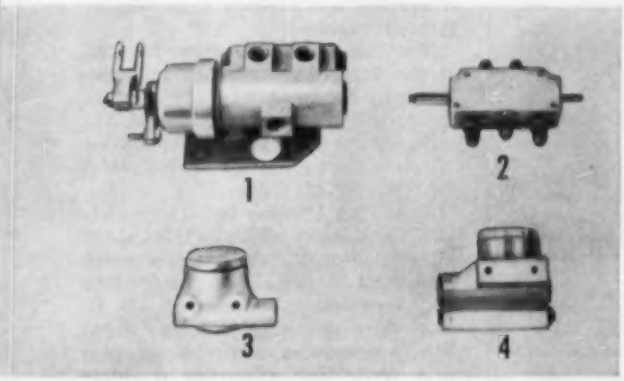
Walter Kidde & Company, Inc., *Aviation Division*
618 Main Street, Belleville 9, N. J.
Walter Kidde & Company of Canada Ltd., Montreal



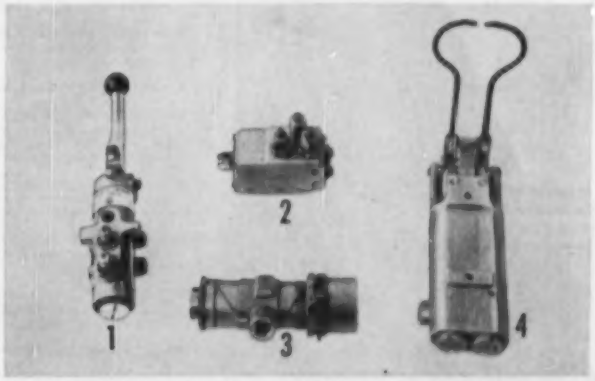
LIGHTWEIGHT AIR COMPRESSORS Rugged, tested 2, 4, 6, 8 and 12 (illustrated) cfm air compressors delivering air at 3,000 or 5,000 psi. Driven by air turbine, hydraulic, electric motor, gear box or direct engine pad.



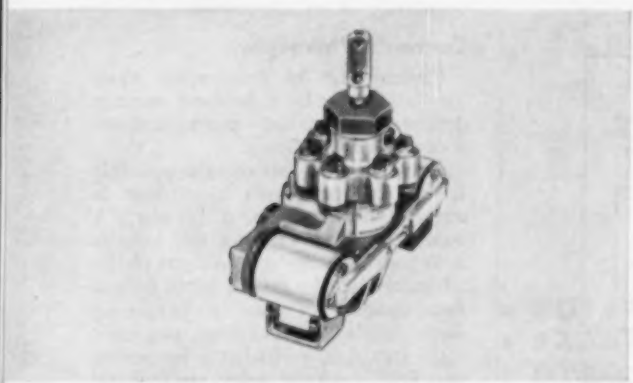
PRECISION VALVES AND OTHER DEVICES 1) Propeller Brake Solenoid Valve; 2) Drain and Blowdown Valve; 3) Three-Port Manual Control Valve; 4) Relief Valve (3000 psi); 5) Pressure Relieving Device; 6) Air Filter.



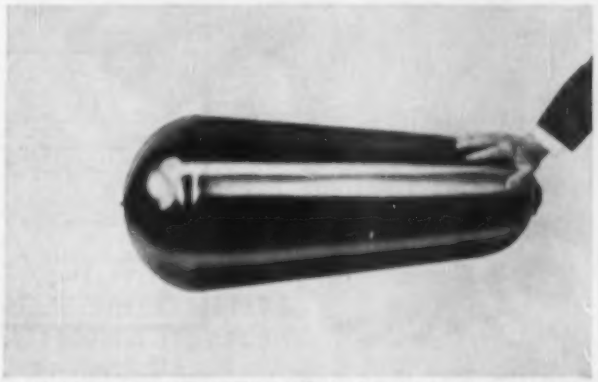
SERVO VALVES AND FUSES 1) Pneumatic Steering Servo Valve; 2) High Temperature-Pressure Pneumatic Servo Valve; 3) 1500 psi Pneumatic Fuse; 4) High Sensitivity Pneumatic Fuse.



BRAKE VALVES AND REGULATOR 1) Pneumatic Emergency Brake Valve; 2) 0-1000 psi Brake Valve; 3) 3300-1000 psi Pressure Reducer; 4) Pneumatic Dual Emergency Brake Valve.



PNEUMATIC VALVE AND ACTUATOR For attachment, operation and release of drag chute.



PNEUMATIC AIR STARTER BOTTLE Has a capacity of 2950 cubic inches. Handles pressures up to 3000 psi.

OTHER IMPORTANT KIDDE AIRCRAFT PRODUCTS: Quick Disconnect Fittings, Gun Chargers, Nose Wheel Steering Systems, Air Brake Valves, Hand Portables, Inflation Gear, Oxygen Equipment, Purging Equipment, Crash Fire Prevention Equipment, Fuel Pressurization Equipment, components of Pneumatic Systems.

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money for a 100-ft. square turning basin to be installed at the end of the existing tank to check taxi-turn characteristics.

A new $400,000 air flow facility that is fairly unusual in the industry is capable of testing complete pneumatic systems such as the bleed air network of a jet fighter in a wide range of conditions.

It includes a USAF-owned electronic equipment cooling chamber in which avionic gear is subjected to heating such as a fighter penetrating the thermal thicket might encounter. This allows checking of the ability of the pneumatic system to cool avionic systems.

An older air flow facility now is carrying air at high temperatures and pressures to study the use of precompressor water injection cooling for turbojet engines.

The Astronautics Division has one of the larger division-owned test sites at nearby Sycamore for static firing of the rocket motor of the Atlas ICBM and other large rockets. Quiet-running missile components are tested at a facility on Point Loma.

San Diego Division has a large electronics laboratory which includes about $2 million worth of company-owned equipment. A partial list includes four microwave ranges—one is 30,000 ft. long—three microwave anechoic chambers, a microwave inerferometer, near field phase and amplitude recording equipment for verifying theoretical antenna problems, a 1,500-ft. microwave boresight range with an accuracy of 0.2 mil angular deviation, and the beginnings of an infrared lab.

Convair's Philosophy

Expenditures of this order, when they are made by a business concern dedicated to making profit, indicate a compelling motive.

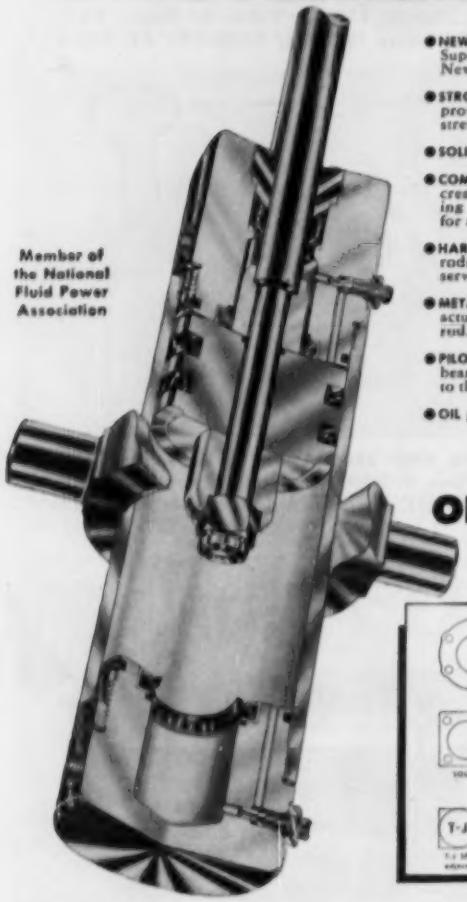
Dr. Critchfield explains the principle behind the company's investment in research and development this way: "A manufacturer of airplanes and missiles is so dependent on the products of the laboratory that he cannot afford to lack understanding of what is happening there. And as is well-known, you can't really stay abreast of what is happening in a field of science unless you're working in the laboratory yourself.

"Another purpose our work serves is to maintain a demand and a training ground for young scientists. Traditionally, these are the functions of the universities. But because of the pressure of enrollments and the backward attitude toward research of some state legislatures, they are falling down on the job to some extent.

"Because of the distribution of wealth in this country it is logical for private industry to take some of the responsibility. We think it is profitable." ■

all the EXTRAS are standard with

T-J Spacemaker CYLINDERS



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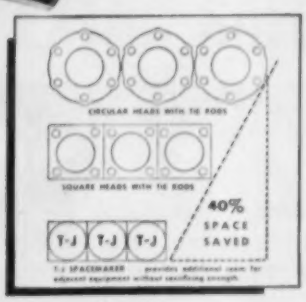
- NEW *exclusive* ingenious cushion designs . . . Super Cushion Flexible Seals for Air . . . New Self-Aligning Master Cushion for Oil.
- STRONGER than outmoded tie rod design, proven through actual tests. No tie rods to stretch.
- SOLID STEEL HEADS throughout the full line.
- COMPACT DESIGN eliminates tie rods, increasing the strength and reducing mounting space required, providing extra room for adjacent equipment.
- HARD CHROME PLATED body bores and piston rods . . . assure you of long trouble-free service. (Standard at no extra cost.)
- METALLIC ROD SCRAPER, not just a wiper, actually removes foreign matter from the rod.
- PILOTED PACKING GLAND with extra long bearing. Additional strength and support to the piston rod.
- OIL pressure to 750 p.s.i. AIR to 200 p.s.i.

DELIVERY OFF THE SHELF!



You *save 40% space* when you switch from outmoded tie rod cylinders to the T-J Spacemaker! It's stronger, too! Fits right into automation programs in countless plants. Delivers top performance and dependability with a big *plus* in advanced features. Wide range of styles, capacities . . . reduces man-hours and costs in all kinds of push-pull-lift jobs. Off-shelf delivery in 64,000 combinations!

NEW LITERATURE—Send today for new Catalog SM56 with complete engineering details on Spacemaker line. Write The Tomkins-Johnson Co., Jackson, Mich.

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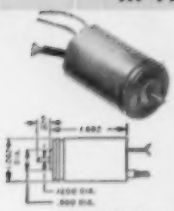
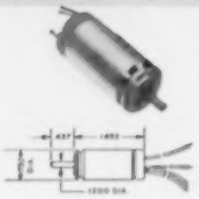
Publication No. 5612-13
Supersedes Publication No. 563-1

AY-190 SERIES, SIZE 11 FRAME — AUTOSYN® SYNCHROS — AY-300 SERIES, SIZE 8 FRAME



Function	Corrosion Resistant
Transmitter	AY-190-A1
Control Transformer	AY-191-A1
Resolver	AY-192-A1
Differential	AY-193-A1
Receiver	AY-194-A1*

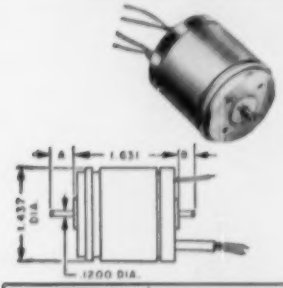
* Receiver not normally furnished in corrosion resistant construction.



Function	Corrosion Resistant
Receiver	AY-300-2-A1*
Control Transformer	AY-300-25-A1
Transmitter	AY-300-26-A1
Control Transformer (HI-Z)	AY-300-38-A1
Resolver	AY-320-25-A1
Differential	AY-330-25-A1

* Receiver not normally furnished in corrosion resistant construction

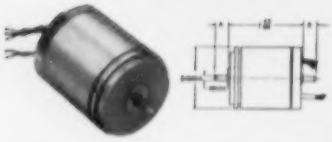
AY-200 SERIES AUTOSYN SYNCHROS — SIZE 15 FRAME



TYPICAL No.	Dimension A	Dimension B
AY-200-1	¼	0
AY-201-1	½	0
AY-202-1	7/16	⅜

FUNCTION	STANDARD CONSTRUCTION	CORROSION RESISTANT	HIGH TEMPERATURE
Multi-Power Transmitter	AY-20 ☐S-1-B	AY-20 ☐S-44-B	
Receiver	AY-20 ☐S-2-B		
Control Transformer	AY-20 ☐S-3-B	AY-20 ☐S-25-B	
Single-Power Transmitter	AY-20 ☐S-4-B	AY-20 ☐S-26-B	AY-20 ☐S-31-B
Control Transformer (HI-Z)	AY-20 ☐S-5-B	AY-20 ☐S-38-B	
Linear		AY-21 ☐S-42-B	AY-21 ☐S-48-B
Resolver (HI-Z)	AY-22 ☐S-5-B	AY-22 ☐S-38-B	
Resolver	AY-22 ☐S-27-B	AY-22 ☐S-25-B	
Differential (Servo Application)	AY-23 ☐S-3-B	AY-23 ☐S-25-B	
Differential (Synchronous Application)	AY-23 ☐S-4-B		
Resolver (Omni Application)	AY-24 ☐S-5-B		
Resolver (HI-Frequency)	AY-25 ☐S-24-B	AY-25 ☐S-39-B	
Resolver, Control Transformer	AY-26 ☐S-3-B		
Variable Transformer	AY-27 ☐S-43-B	AY-27 ☐S-46-B	AY-27 ☐S-46-B

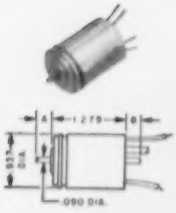
AY-400 SERIES AUTOSYN SYNCHROS — SIZE 22 FRAME



TYPE No.	Dimension A	Dimension B
AY-401-1	½	0
AY-402-1	½	½

FUNCTION	STANDARD CONSTRUCTION	CORROSION RESISTANT
Transmitter	AY-40 ☐-1-A	AY-40 ☐-2-A
Differential	AY-43 ☐-1-A	AY-43 ☐-2-A

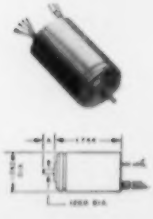
AY-500 SERIES "PYGMY" AUTOSYNS — SIZE 10 FRAME



TYPICAL No.	Dimension A	Dimension B
AY-500-2	¼	0
AY-502-2	¼	¼
AY-503-2	⅜	0

FUNCTION	STANDARD CONSTRUCTION	CORROSION RESISTANT	HIGH TEMPERATURE
Receiver	AY-50 ☐-2-A1		
Control Transformer	AY-50 ☐-3-A1	AY-50 ☐-25-A1	
Transmitter	AY-50 ☐-4-A1	AY-50 ☐-26-A1	AY-50 ☐-8-A1
Control Transformer (HI-Z)	AY-50 ☐-5-A1	AY-50 ☐-38-A1	
Linear	AY-51 ☐-10-A1		
Resolver	AY-52 ☐-3-A1	AY-52 ☐-25-A1	
Differential	AY-53 ☐-3-A1	AY-53 ☐-25-A1	
Resolver (HI-Z)	AY-54 ☐-5-A1	AY-54 ☐-38-A1	
Resolver (HI-Frequency)	AY-55 ☐-24-A1	AY-55 ☐-39-A1	

AY-600 SERIES AUTOSYN SYNCHROS — SIZE 11 FRAME



TYPICAL No.	A INCHES
AY-600-1	5/16
AY-601-1	½

FUNCTION	STANDARD CONSTRUCTION	CORROSION RESISTANT	HIGH TEMP. AND CORROSION RESISTANT
Multi-Power Transmitter	AY-60 ☐-1-A1	AY-60 ☐-6-A1	
Control Transformer	AY-60 ☐-3-A1	AY-60 ☐-5-A1	AY-60 ☐-12-A1
Control Transformer (Med. Z)		AY-60 ☐-11-A1	AY-60 ☐-9-A1
Receiver	AY-60 ☐-10-A1		
Single-Power Transmitter	AY-60 ☐-8-A1		
Resolver	AY-62 ☐-3-A1	AY-62 ☐-5-A1	
Differential		AY-63 ☐-5-A1	AY-63 ☐-12-A1

Units listed have loose leads. Can also be furnished with terminal boards.

LOW INERTIA SERVO MOTORS

TYPE No.	RATED VOLTAGE Phase 1	RATED VOLTAGE Phase 2	Max. Power Input Total (Watts)	No Load Speed (RPM)	Stall Torque (Oz. in.)	Torque to Inertia Ratio (Radians-sec.^{2})	Frame Size	REMARKS
CK-1018-7-A1	18	18	5.0	10,000	0.13	18,400	10	Tapered Shaft
CK-1018-16-A1	26	26	6.0	10,000	0.3	40,000	10	125°C Ambient Temp. Corrosion Resistant, Tapered Shaft MK 7 Mod. 1
CK-1025-13-A1	115	115/57.5	12.0	4,800	1.45	31,000	15	
CK-1027-14-B1	115	115/57.5	7.0	6,200	0.60	41,500	11	
CK-1027-15-B1	115	180/90	7.2	6,200	0.60	41,500	11	
CK-1031-18-A1	26	55	9.0	6,175	0.35	10,000	10	Corrosion Resistant
CK-1038-17-A1	26	50	4.75	5,500	0.39	14,500	15	Pinion on Tapered Shaft
CK-1041-19-A1	26	65	6.6	3,600	0.7	3,500	15	Drag Cup
CK-1043-17-A1	26	50	4.75	5,500	0.39	14,500	15	Tapered Shaft
CK-1045-16-A1	26	26	6.0	10,000	0.3	40,000	10	125°C Ambient Temp. Corrosion Resistant, Splined Shaft
CK-1048-24-A1	18	18	3.0	6,300	0.15	21,300	8	Splined Shaft
CK-1048-29-A1	26	26	4.5	6,300	0.20	28,300	8	Splined Shaft
CK-1049-25-A1	26	26	6.5	5,800	0.35	19,000	8	Splined Shaft
CK-2006-5-A1	115	115	30.0	6,600	3.0	5,700	20	
CK-2006-13-A1	115	115	26.0	6,000	2.5	41,500	20	Corrosion Resistant
CK-2011-13-A1	115	115	26.0	6,000	2.5	41,500	20	Corrosion Resistant
CK-3004-4-A1	115	230	70.0	3,700	14.5	5,800	28	

RATE AND SERVO MOTOR GENERATORS

TYPE No.	RATED VOLTAGE Phase 1	RATED VOLTAGE Phase 2	Max. Power Input Total (Watts)	No Load Speed (RPM)	Stall Torque (Oz. in.)	Torque to Inertia Ratio (Radians-sec.^{2})	Gen. Excit. (Volts)	Generator Output (Volts)	Frame Size	REMARKS
FV-10 □-5-A1	26	26	7.0	10,000	0.28	20,000	18	0.3/1000	10	Corrosion Resistant
FV-103-6-A1	115	115/57.5	7.0	6,200	0.60	25,500	115	0.5/1000	11	
FV-104-7-A1	26	26	9.7	6,000	0.50	22,000	26	0.5/1000	11	High Temperature Corrosion Resistant
FV-109-10-A1	26	26	7.0	10,000	0.28	14,000	18	0.3/1000	10	Includes Permanent Magnet Generator for Speed Measurement
FV-110-9-A1	26	52/26	7.0	10,000	0.28	20,000	26	0.5/1000	10	Corrosion Resistant
FV-110-12-A1	33	52	7.0	10,000	0.28	20,000	26	0.5/1000	10	Corrosion Resistant
FV-112-11-A1	18	18	3.0	6,300	0.15	13,000	18	0.25/1000	8	Corrosion Resistant
FV-2001-4-A1	115	115	23.0	7,200	2.5	69,000	18	0.3/1000	20	Corrosion Resistant
FV-2005-5-A1	115	115/57	26.0	6,000	2.5	39,000	115	0.5/1000	20	Corrosion Resistant
FV-2007-6-A1	115	115	25.0	7,000	2.8	5,400	18	0.3/1000	20	Corrosion Resistant
FV-3005-5-A1	115	230/115	70.0	3,700	14.5	4,200	115	0.5/1000	28	

RATE AND SERVO MOTORS — CENTER TAPPED CONTROL WINDINGS

TYPE NUMBER	FRAME SIZE	CONT. PHASE VOLT.	CENTER TAPPED CONTROL PHASE TOTAL Z	R	X	POWER CONT. PHASE	FIXED PHASE VOLT.	FIXED PHASE Z	R	X	POWER FIXED PHASE	EFFECTIVE RESISTANT CONTROL PHASE	TORQUE
1265271	8	55	750	597	450	3.19	26	170	142	93	3.25	960	.3
1265272	10	52	584	419	405	3.3	26	146	105	101	3.3	830	.3
1265273	11	40	263	151	215	3.5	115	2175	1250	1780	3.5	460	.63
1269605	8	26	290	240	158	2.2	26	290	240	158	2.2	310	.2
1269606	10	26	290	240	158	2.2	26	290	240	158	2.2	310	.2
FV100-12-A1	10	33	241	175	167	3.3	26	146	105	101	3.3	335	.3
1269702	8	52	680	568	372	3.25	26	170	142	93	3.25	830	.3

ORDNANCE AND NAVY TYPE AUTOSYN SYNCHROS

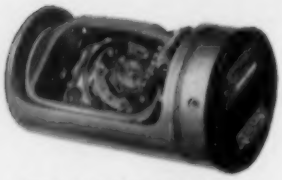
TYPE No. ECLIPSE-PIONEER	TYPE No. MILITARY	FUNCTION
AY-1601-5	15TR4A	Torque Receiver
AY-2400-9	23CX6	Control Transmitter
AY-2400-10	23CT6	Control Transformer
AY-2400-12	23TX6	Control Transmitter
AY-2400-13	23TR6	Torque Receiver
AY-2401-10	23CT6A	Control Transformer
AY-3200-9	31TX4A	Torque Transmitter
2323-1	1HCT	Control Transformer
2324-1	1HG	Transmitter
2325-1	1HDG	Differential Transmitter
2326-1	3HCT	Control Transformer
2327-1	3HG	Torque Transmitter

TYPE No. ECLIPSE-PIONEER	TYPE No. MILITARY	FUNCTION
2328-1	3F	Receiver
2330-1	1F	Receiver
2340-1	5HG	Transmitter
2341-1	5F	Receiver
2343-1	1D	Differential Receiver
2344-1	6HG	Transmitter
2345-1	3D	Differential Receiver
2346-1	5SCT	Control Transformer
2352-1	5HDG	Differential Transmitter
2353-1	5HCT	Control Transformer
2369-1	6HDG	Differential Transmitter

PRECISION GYROS FOR ALL APPLICATIONS

Eclipse-Pioneer . . . the nation's foremost supplier of panel indicator gyros . . . offers a complete line of gyros to meet all applications. This group includes all the basic vertical, rate, free, and directional gyro types used as reference components in complete navigation, radar, compass, autopilot, and guidance systems.

VERTICAL GYRO TRANSMITTERS



Type Number 14110-1-A

FEATURES: Includes quick erecting mechanism which makes the remote unit ready for operation within 3 minutes. • Two ball erection system • Non-tumbling stops • Inclined axis (1 degree) to minimize turn error.

Power requirement	115 volts, single phase, 400 cps	**Autosyn excitation**	26 volts, 400 cps
Starting	19 watts, 0.9 P.F.	**Erection rate (normal)**	3°/minute
Running	13 watts, 0.85 P.F.	**Weight**	2¾ lbs.
Gyro speed	22,000 rpm	**Size**	3⅛" diameter x 5 1/16" long
Gyro moment	600 gram cm²		

Type Number 14104-1-B

Diameter — 6⅛" Weight — 6¼ lbs. Height — 6¾"

Designed for use as a remote vertical reference where vertical stabilization is required. The instrument is essentially an electrically driven, vertical-seeking gyro with separate Autosyn transmitter pick-offs on the pitch and bank axes. Provisions are incorporated to reduce bank error encountered in turns.

- **Operating temperature range:** —55°C to +70°C.
- **Operational limits:** 360° in roll and pitch with controlled tumbling of the pitch axis at near 90°.
- **Accuracy:** The erection system maintains the gyro in a vertical position to within ¼° of vertical position with respect to the earth.
- **Caging:** From any position at full rotor speed in less than 45 seconds.

Type Number 14126-1-A

This Vertical Gyro Transmitter provides roll and pitch displacement signals which will operate remote indicating devices or which can be used wherever attitude information could be applied. It consists of an electrically driven, torquer erected, vertical-seeking gyro enclosed in a hermetically sealed case with separate Autosyn transmitter pick-offs on the roll and pitch axes.

Provisions have been made so that the pitch and roll erection systems can be cut out by external switches.

An outstanding feature of this instrument is the use of the newly developed Eclipse-Pioneer Electrolytic Switch which provides precise erection and has long serviceability. Besides being rugged, of simple design, and easily serviceable, the transmitter also features a quick erection to true vertical instead of vertical in relation to the instrument case; a sensitive measuring vertical detection system with an accuracy of better than ¼°; and an improved gimbal construction resulting in greater operational stability. This gyro is completely self-contained and requires no erection amplifier.

Size: 4¼" diameter, 8 31/32" in length
Weight: Approx. 6 lbs. without shockmount
Power requirements: Gyro Motor and Erection System — 115 volts, 400 cycles, 3 phase
Autosyn — 26 volts, 400 cycles, 1 phase

VERTICAL GYRO—Non pendulous

Momentum: 4,000,000 gm cm²/sec

Freedom: 360° in roll. Controlled tumbling near ± 82° in pitch with stops set to provide minimum loop error at 10°/sec rate of loop

RADAR ANTENNA DEVICES

GROUND ANTENNA PEDESTAL TYPE NUMBER 40101-1-A

SPECIFICATIONS

Weight	700 lbs.
Data accuracy	0.5 Mil.
Slewing rates (in azimuth and elevation)	12 rpm.
Operating temperature range	—54°C to +66°C
Elevation and Azimuth Servo drives	Two-speed 60 cps synchro data systems are used, having ratios of 1:1 and 16:1
	⅜ HP motors (DC) for use with an Amplidyne servo system
Wind loading	50 mph (full operating performance) 100 mph (no structural damage)

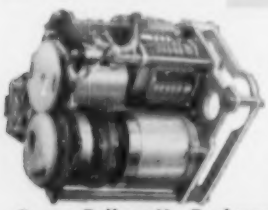
SPECIFICATIONS

Standard frequency range	9345 tto 9405 mc/s. This permits beacon operation at 9310 mc/s
Optional frequency range	9215 to 9275 mc/s
Operation	Up to 60KW peak with a 0.001 duty cycle
Beam width	4° maximum in E and H planes
Side lobes	At least 18 db below main lobe peak
Polarization	Horizontal
Weight	24 lbs. (approximate)
Operating temperature range*	—40°C to +55°C
Storage temperature range*	—65°C to +55°C
Humidity	10% to 95%

*These temperature ranges can be extended for specific applications.

AIRBORNE WEATHER RADAR ANTENNA TYPE NUMBER 40023-□-A

COMPONENT PACKAGING



Servo Follow-Up Package

External Slip Ring Autosyn

In addition to supplying catalog component items such as — synchros, motors, gyros, etc. — Eclipse-Pioneer is in an excellent position to offer a premium in the way of customer service and accommodation on component packaging.

We may have already solved a problem similar to yours, thus enabling our system specialists to adapt from our extensive line, existing production packages to meet your systems requirements.

Should your problem turn out to be entirely new, we can — and will — design, develop, and produce a component or complete system to solve your specific problem.

No package is too small or too large for Eclipse-Pioneer, and may be as simple as an Autosyn mounting clamp or be more complex such as a complete servo follow-up subassembly from a production computer.

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TETERBORO, NEW JERSEY

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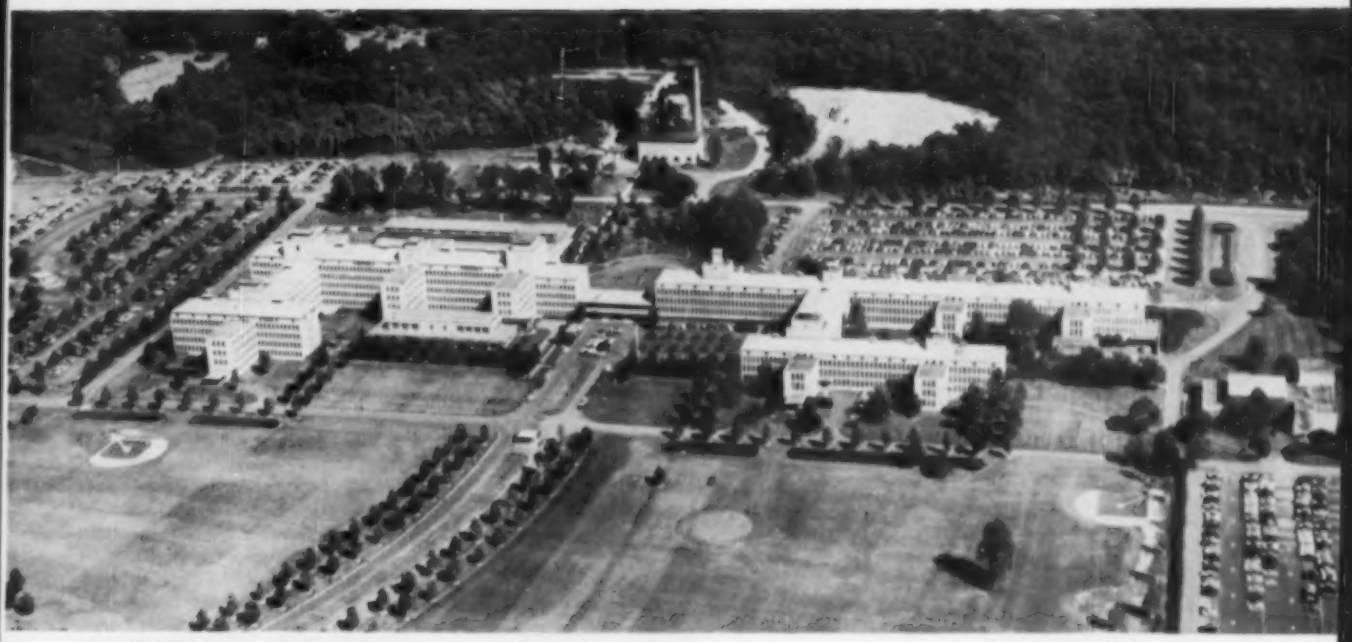


BELL TELEPHONE LABORATORIES research, development and some systems engineering are centered at Murray Hill, N. J.

Bell Advances Avionics on Wide Front

By Philip J. Klass

If Bell Telephone Laboratories in its more than 30 years of existence had produced but one discovery—the transistor—its contribution to aviation and military defense still would be felt for decades.

This would be true even if the transistor were an end in itself, instead of the first of a whole new family of solid-state devices that promise to reshape radically the art of electronics.

The transistor is but one of many significant developments to come out of BTL's search for fundamental understanding in the field of communications and related arts. Because the future progress of aviation and defense is becoming increasingly dependent upon new advances in these fields, BTL's future contributions may easily surpass those of the past.

Scope of BTL's Effort

With more than 3,100 professional scientists and engineers, and an annual budget of around $150 million, BTL's activities today probably represent between 5 and 10% of the nation's total research and development effort in electronics and communications.

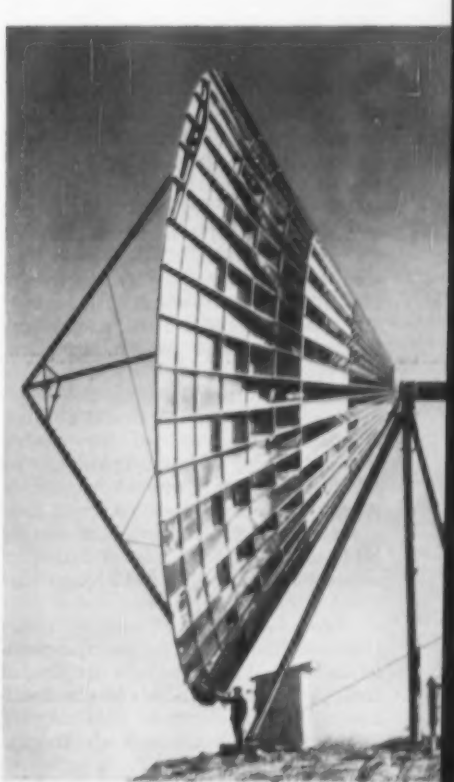
Ten years ago, before the advent of large-scale military sponsorship of research and development, BTL's efforts probably represented close to 25% of the nation's total activity in this field.

Because Bell Telephone Laboratories' activities include fundamental research, development, design and systems engineering, BTL is representative of the efforts of hundreds of avionics manufacturers and several dozen industrial, private and university research groups. Yet the ground rules which BTL operates make it unique in many ways.

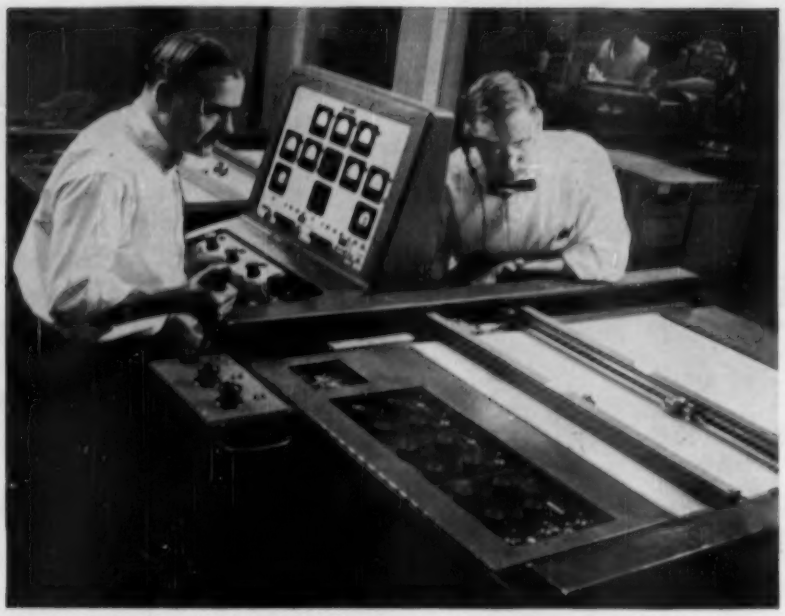
These contradictory characteristics both stem from the fact that BTL was founded to advance the state of the communications art for its parent organization, American Telephone & Telegraph Co., and to assist its sister organization, Western Electric. This remains BTL's primary goal.

The company has not followed the example of many others—General Electric for example—of exploiting new research discoveries, such as silicones and synthetic diamonds, to move into fields outside main-stream activities. Generally speaking, BTL points only toward knowledge or devices needed by the parent company for present activities, and does not seek new lines of business endeavor.

Although this might appear to circumscribe seriously the areas of BTL's research and development, the technology of communications has become so complex and embraces so many of the scientific disciplines that BTL's ef-



SCATTER communications and other propagation research are carried out at BTL facility located at Holmdel, New Jersey.



BTL missile simulator has "flown" 30,000 Nike missions, is time and money saver.

forts range from the sub-microscopic inner workings of the atom to the heavens, whose little-understood radiations have significant effects on radio communications.

This great diversity makes BTL's contribution to aviation and the defense effort far greater than might be expected from the number of its scientists engaged in specific defense projects. Approximately one-third of the professional scientists and engineers here work on specific defense projects which make up about 50% of BTL's annual budget.

Important Defense Tasks

In this day of mass scientific attacks on weapon system development, 1,000 scientists in military work appears a modest number compared to many other defense contractors, particularly in view of the major programs assigned to BTL and Western Electric.

BTL holds development and engineering responsibility for the Nike missile, guidance systems for two of the Air Force ballistic missiles, the DEW Line radar net in the Arctic and several other important defense programs. Despite the modest numbers, BTL and Western Electric have a record of highly successful accomplishment.

The bulk of BTL's scientists make their contributions to the defense effort in less obvious but equally important areas. For example, BTL's fundamental research, usually company financed, has produced or promoted such advances as:

- **The transistor.**
- **Scatter communications,** so vital to military communications in the Arctic.
- **Ferrite isolator,** now widely used in radars to prevent unwanted signal reflections from adversely affecting transmitter performance.
- **Greatly improved magnetic materials.**

More than half of Bell Telephone Laboratories' manpower is devoted to improving and expanding the capabilities of A.T. & T.'s communication service—the lifeline of industry and defense, including the SAGE air defense system.

Although BTL recognizes its responsibility to take on difficult defense programs, it also believes that in peacetime it must devote sufficient effort to assuring that A.T. & T.'s lifeline will be able to meet the future demands of both civil and military users.

For this reason its officials try to limit defense activities to approximately the present ratio. This makes BTL almost unique among defense contractors in that it never seeks military work, and must often turn it down. BTL encourages the military to seek its services only when no other suitable contractor can be found, and when the program carries a high priority. Without such limitations, BTL probably would find itself almost completely devoted to defense work.

How BTL Is Organized

The laboratories are divided into six operating groups, called Vice Presidential Areas for lack of a more suitable term. Each is headed by a BTL vice president. The six groups, their individual percentage of BTL's total professional staff, and the vice president in charge are:

- **15% Research: Dr. W. O. Baker.**
- **35% Development—Transmission and Switching: W. A. MacNair.**
- **15% Development—Outside and Station Equipment: M. H. Cook.**
- **10% Systems Engineering: E. I. Green.**
- **13% Military Systems: R. R. Hough.**
- **12% Military Systems: W. C. Tinus.**

Research and Development area activities are centered at Murray Hill and Holmdel, N. J., Military Systems at Whippany, N. J., and Systems Engineering in New York City and Murray Hill. BTL also has a number of satellite groups around the country.

Research Philosophy

Objective of BTL's research is to coax nature to give up more of her secrets, to discover and gain fundamental understanding of physical phenomena, according to Dr. W. O. Baker, vice president of the research area.

More broadly stated by Dr. Marvin J. Kelly, BTL president, the objective is to provide "coupling between the ever-advancing forefront of pure science and the forward march of our communications technology."

Very few of BTL's research tasks are under military sponsorship, either directly or indirectly. The reason, according to Baker: "Our job is to discover what the military does not yet know it wants or needs." Another reason is that fundamental research, unlike development or production, cannot be scheduled.

Another interesting difference between fundamental research and an engineering project is that research usually is the work of a few minds and does not lend itself to mass attacks.

Although BTL research often leads to significant breakthroughs like the transistor, its objective usually is not

BTL military systems activities, such as Nike, are located at Whippany, N. J.

new devices or techniques as such. When BTL started the research program in the mid 1930's that eventually led to discovery of the transistor, it was not looking for a replacement for the vacuum tube.

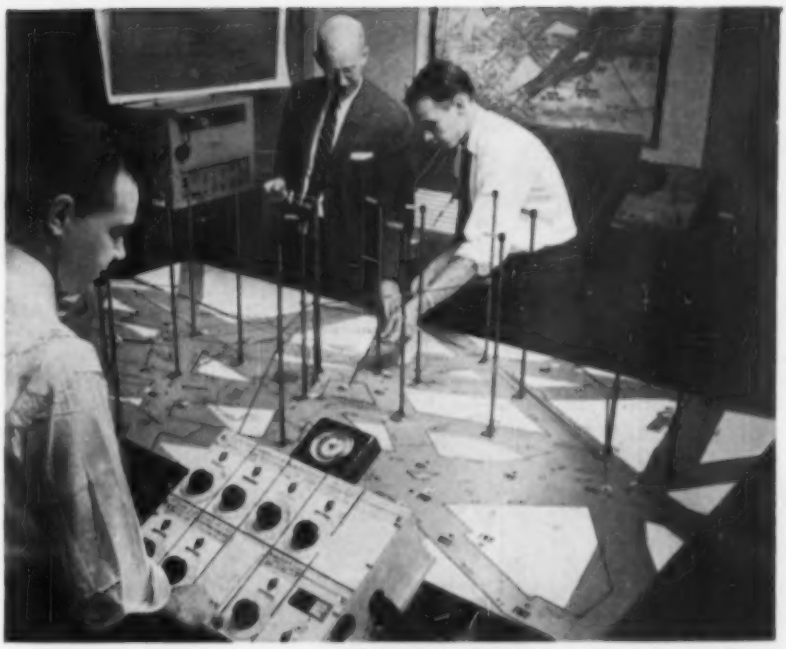
Rather, BTL officials recognized that work in quantum theory had opened the door to a new field of scientific investigation—what today is called solid-state physics.

A group of young scientists was formed to seek basic understanding of solid-state phenomena. It was not until more than a decade later, in 1948, while researchers were seeking to understand the nature of semiconductor surface, that they discovered the transistor principle. Several years earlier the idea occurred to members of this group that it might be possible to control the flow of current in a semiconductor, and thus to produce transistor action, but the actual invention occurred in quite an unexpected way, according to Baker.

A more recent example of the way that a search for basic knowledge can produce technological breakthroughs in devices is the Maser, or spin oscillator. Spectroscopy employs visible light to determine the composition and characteristics of gases or other partially transparent materials by determining which portions of the visible spectrum are absorbed by them.

In 1946, Dr. Charles Townes (then with BTL, now at Columbia University) saw the possibility of using microwave techniques developed for wartime radar instead of visible light in spectroscopy to study the structure of molecules in gases. His idea was that each material would have characteristic absorption bands in the microwave frequencies similar to those in the visible spectrum.

BETTER transistors come from BTL research in metallurgy and chemistry.



BTL systems engineering includes studies of air traffic control and communication problems.

From this early search for better understanding, and efforts by BTL, Harvard, Massachusetts Institute of Technology and other research groups, came the solid-state spin oscillator, or Maser, which holds promise of providing major gains in the performance of radar and communication systems.

Creative Environment Necessary

Productivity of a research group can be greater or less than the sum of the skills of its individual members. The determining factor often is the environment in which the researchers work.

Scientists in BTL's research effort usually hold PhD's and are what Baker calls "individual scholars"—scientists capable of carrying on independent research. When a scientist joins the laboratory, he seldom is assigned to a specific research task. Instead he is urged to look around until he finds an area or a problem which he finds interesting and challenging.

BTL officials believe their researchers must enjoy full freedom to select projects which arouse their scientific curiosity. For example, a development engineer in another BTL area may have a pressing problem which he believes requires fundamental research effort. Yet there is no way in which he can bring topside pressure upon the research group, or any individual in the group, to tackle the problem.

The development engineer either must find a researcher who is interested or he must arouse the researcher's interest. Baker said the researcher must always have the right to say no.

In a research organization, the organizational chart must be extremely flexible and tailored to the individual, rather than forcing him to conform to a master plan, Baker says. This frequently results in an organization chart that makes good scientific sense even though it does not conform to accepted industrial organization practices.

Barriers which previously appeared to separate different scientific disciplines are fast disappearing in research. The transistor, for example, draws on the efforts of chemists, physicists and metallurgists as well as electronics engineers.

With close to 500 scientists in research, communication of findings between researchers assumes major importance. What might appear to be an unimportant observation in a chemical research experiment may hold profound implications in metallurgy.

"Unnecessary duplication," Dr. Baker says, "is the malignancy of science and the disease of progress." To maintain communications between members of the staff, BTL relies heavily on informal lines of communications.

One of these is the technical memorandum, or MM. Scientists are encouraged to write up even preliminary findings in MMs. These are circulated to anyone in the laboratory who might be interested. Even wider distribution is made in a monthly listing of the titles of MMs issued by all staff members. To encourage this medium of communication, no special approval or editorial excellence is required.

Seminars and informal gatherings are another important medium of exchange. In certain areas such as semi-

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conductors, which involve scientists from a large number of groups, regular meetings are held every two weeks. Many of these are attended by members of semiconductor device development groups to learn of new research advances and to report current problem areas which may attract research.

Supervisor's Role

In research activities one of the supervisor's primary tasks "is to create the right climate," according to A. H. White, director of the semiconductor research sub-department. The supervisor must also be alert to suggestions from scientists which may lead to opening new fields for exploration.

Another major responsibility of the supervisor is to maintain close contact with the efforts of his scientists in order to spot gaps in the attack which may merit efforts by others and to arouse interest in exploring these areas.

Unless a field of investigation is challenging, it is difficult to get good scientists to work in it, White points out. A supervisor therefore must recognize when a research area is beginning to lack appeal and either transfer men to other activities or broaden the area to bring in interesting new problems.

These requirements demand that a supervisor have considerable scientific competence in his field. Most at BTL are PhD's.

"The true scientist has a very strong motivation to both find and reveal the truths of nature," White says. Furthermore, interchange of knowledge through publication is the life blood of scientific advance. When scientists are restrained from publishing the results of their research, they tend to lose interest, he said.

BTL vigorously encourages its scientists to publish the results of their labors.

Three Research Departments

Within the laboratories, fundamental research is carried out by three general departments which report to Baker:

- **Physical Sciences, headed by Dr. H. W. Bode.**
- **High Frequency & Electronics, under Dr. H. T. Friis.**
- **Electrical Communications, headed by Dr. J. R. Pierce.**

The Physical Sciences department embraces nearly all the fundamental sciences, including organic and physical chemistry, solid-state physics, metallurgy and mathematics.

There is no basic research in aerodynamics as such, but the mathematics group under Dr. Bode made the preliminary aerodynamic control studies for Nike and has performed similar tasks for other systems developed by the Military Systems group at Whippany.

Semiconductor research is a significant part of this department's work. One phase of this program seeks better understanding of the properties of new semiconductor compounds, which are made from two elements instead of a single element like germanium or silicon. One material under study is gallium arsenide, which appears to have theoretical possibilities of raising the top operating temperature of transistors from the present 200-300C limit to the 600-700C range.

One problem with gallium arsenide in trying to grow single crystals is that the material decomposes at its melting point, but BTL researchers believe that this can be solved.

Another program seeks to understand why semiconductors behave as they do at extremely low temperatures near absolute zero. Recent experiments revealed that a semiconductor subjected to mechanical stress at these temperatures undergoes a change in resistance 100 to 1,000 times greater than theory had predicted. Purpose of this program is not to find an application for this new discovery but to find out why it does not conform to the old theories. This answer could be far more significant than development of a single new device.

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possible to control accurately the amount and depth of impurity penetration and thereby results in transistors with higher frequency response—has provided a useful new tool for studying chemical structures. This new tool, sometimes called "solid-state chemistry," makes it possible to "dissolve" controlled amounts of two different elements in a solid material, like germanium or silicon, then study their interactions.

High Frequency & Electronics

One of the major efforts of the High Frequency and Electronics Department is in the field of electron beam dynamics, aimed at better understanding of the very complex nature of an electron beam. This knowledge is then applied to research on traveling wave tubes and backward wave oscillators. Recently the group has turned some of its effort to Masers and spin oscillators.

Another major activity, carried out at Holmdel, is in radio propagation, scatter communications and microwave links. This group soon will report on a theory which it has developed, and experimentally verified, to explain variation of tropospheric scatter signal strength with frequency and antenna size.

The Holmdel group also researches the application of new waveguide techniques for wideband transmission and such new devices as ferrite isolators, circulators and spin oscillators. In one sense this group might be called "systems engineers on a research level," Dr. Friis said.

Electrical Communications

The Electrical Communications Department's activities are carried out by three groups:

• **Switching Research,** which seeks new techniques for high-speed switching and data storage. A major program is under way to explore new materials for achieving larger, higher-speed, lower-cost data storage. One recent development is a small computer which can analyze the design of complex switching networks to determine whether they use the minimum possible number of relays.

• **Transmission Research** carries out investigations in such fields as digital communications, using pulse-coded modulation, seeking ways to send more information over existing circuits with greater reliability. Work includes devising new types of cables suitable for digital communications and investigation of new terminal facilities for providing more economical and versatile transmission of voice and pictorial material.

• **Visual and Acoustic Research** delves into the human aspects of communications. A typical investigation is trying to learn what elements of human speech can be deleted in a narrowband

transmission and still retain naturalness. Another seeks to determine how much and in what ways the quality of a TV picture can be reduced, in order to use less expensive transmission facilities, without objectionable deterioration.

One small project established that people with no special training can read patterns of lights representing digits in binary code as quickly and accurately as they can read lighted Arabic numerals.

Researcher Doesn't Develop

In Bell Telephone Laboratories the fundamental researcher may carry his work to the point of constructing an experimental model to demonstrate a principle, but usually no further. Converting new discoveries or techniques into working devices is the responsibility of BTL's development areas.

There are several good reasons for this policy. Once the fundamental researcher has uncovered new knowledge he usually is anxious to get on with other research projects. Secondly, economic factors and time schedules must enter into any hardware development phase and both are foreign to the fundamental researcher.

If a fundamental researcher feels strong motivations in the direction of development he can move into this area. Many of the scientists in development began their careers in research.

Although many of BTL's development activities, such as the design of central office telephone equipment, involve engineering skills predominantly, others such as development of transistors and microwave tubes depend heavily on both engineering and research-type skills.

Devices Department

A good example of the latter can be found in the Devices Department, one of four in the development area headed by MacNair. This department, headed by J. A. Morton, is responsible for development of solid-state devices, electron tubes, and passive components such as resistors and capacitors.

It employs about 25% of the scientists and engineers in MacNair's area, but it has an extremely high percentage of PhD's (about 50%). Many of them came from the research area.

In mid-1948, after fundamental researchers had gained sufficient knowledge of transistor amplification to permit device development, BTL formed a solid-state development group to acquire sufficient knowledge for transistor design.

The design of a transistor appeared deceptively easy. It consisted merely of a crystal of germanium and two tiny cat-whiskers. But, as Morton points

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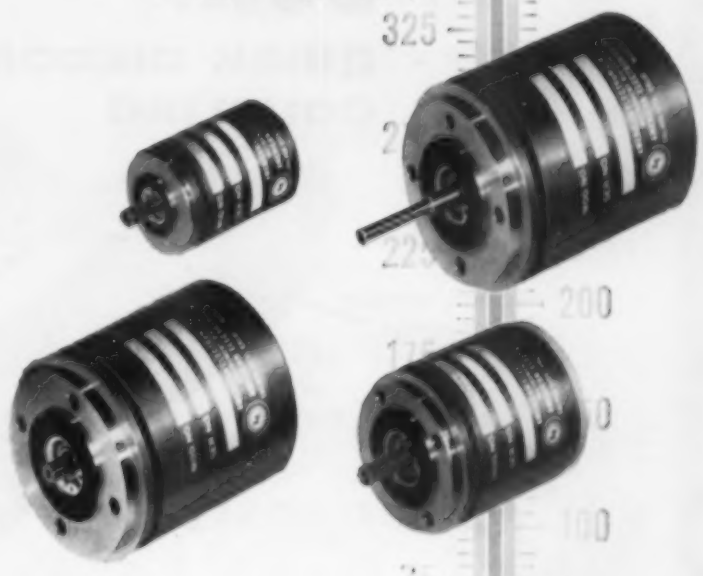

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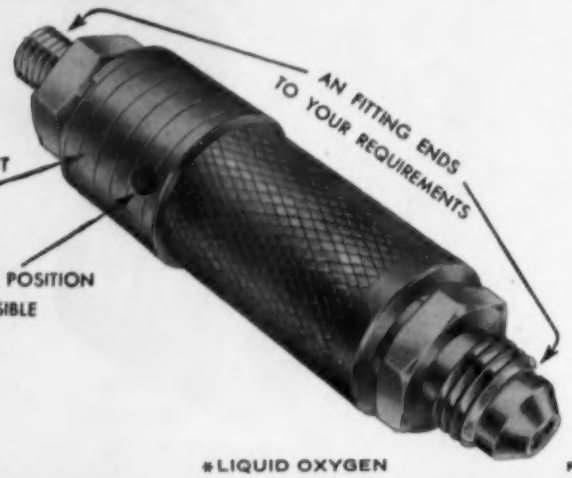

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out, the development group quickly discovered that it was practically impossible to achieve uniform transistor performance characteristics even in pilot production. They concluded, after investigation, that the problem in large part resulted from lack of homogeneity in the germanium. This led to further research and the development of single crystal techniques.

Still later it was found that transistors were falling far short of the expectation that they would have almost indefinite life. After considerable investigation, the development group concluded that contamination by undesired impurities of the germanium crystal probably were responsible. But more basic knowledge of the specific contaminations and the mechanism of contamination were needed, so Morton's group again went to work with the researchers.

Two researchers in different fields, working independently, hit upon one cause of the problem—minute traces of copper in the germanium. The search for ways to avoid this contamination led to development of the new diffusion process which also permitted major gains in transistor frequency range. However, still more work is needed to achieve complete understanding of semiconductor surface problems.

Because solid-state devices are pushing so close to the frontiers of knowledge, there must be extremely close liaison between researchers and device developers. This, Morton said, takes place largely on an informal man-to-man basis. Problems encountered by the devices people often raise challenging new questions and lead to new research projects.

Much of the work in solid-state device development would, in many companies, be called research. This explains why Morton's group consists of so many PhD's and physicists. To develop transistors suitable for specific functions the group must understand the factors that control amplification bandwidth, noise figure, energy levels of output and must have considerable knowledge of materials and processing.

While the research people are going after more basic understanding of the Maser phenomena and seeking a wider range of usable materials, the development group is investigating whether the device can provide sufficient gain, bandwidth and low noise.

Not all developments require continuing research efforts. One example is the magnetron, where all of BTL's efforts now are concentrated in the development area.

This does not mean that future magnetron progress is limited to minor improvements. For example, BTL has developed a new technique for making

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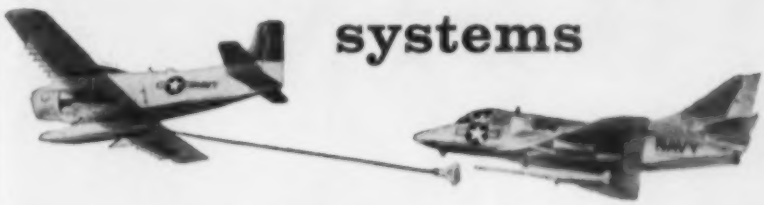

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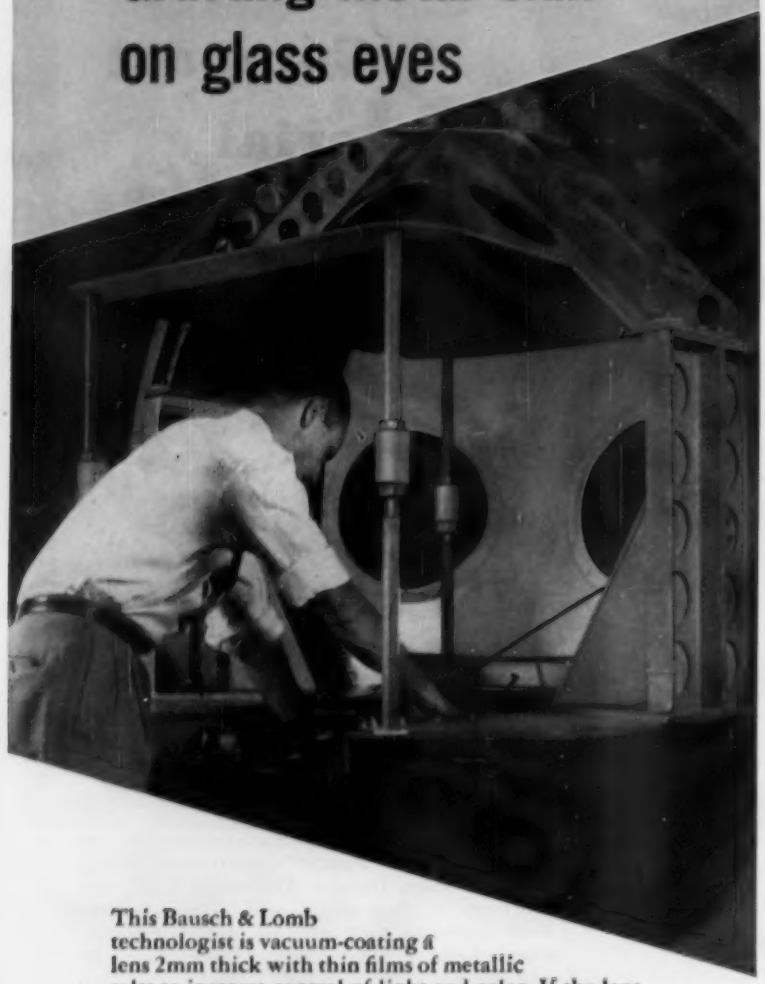

This Bausch & Lomb technologist is vacuum-coating a lens 2mm thick with thin films of metallic salts to increase control of light and color. If the lens were enlarged to the height of Mt. Washington (6,288'), the lens coating would be equivalent to a four-inch transparent layer. This submicroscopic surfacing method, developed by B&L, makes possible miracles in selective reflectance and transmittance of light of any specified wavelengths. Practical applications range from color TV to directional control of guided missiles. How does this kind of advance technology fit in with your contract plans?

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tunable co-axial cavity magnetrons, which Dr. John Hornbeck, head of electron tube development, called "the first major magnetron development since the end of the war." (Hornbeck is former member of the research staff who has moved into development.)

At the end of World War II, BTL decided to bow out of the magnetron business. Then the Whippany Military Systems group came up with a requirement about three years ago that outside suppliers appeared unable to meet, so BTL re-entered the magnetron field.

Roughly 35% of the electron tube group's efforts are pointed toward microwave tubes, including magnetrons, traveling wave tubes and backward wave oscillators. The remainder of its effort is in receiving and storage tubes, the former for its parent company's activities.

Roughly 25% of the device development group's efforts are under military sponsorship, either directly or indirectly, through Whippany. BTL undertakes developments for Whippany only when requirements cannot be met outside the company.

BTL carries its development to a point where Western Electric engineers can take over and put the device, or equipment, into production. To prove out design, BTL will produce pilot line quantities. In the case of tubes this may be as few as 50, or as high as several thousand in the case of transistors.

To permit a smooth transition of responsibility to Western Electric, and to work out development bugs which invariably accompany production of a new device, BTL maintains satellite groups at several WE production facilities. For example, one of four departments under Morton is stationed at Western Electric's Allentown, Pa., plant where the WE produces tubes and transistors.

Systems Engineering

Systems engineering, a fairly recent addition to the military vocabulary, is an old practice at BTL, whose parent company operates the most complex system ever conceived by the human mind. Function of this vice presidential area, headed by E. I. Green, can be summed up as technical planning and control.

With several thousand prolific BTL scientists turning out new techniques and devices, a central group is needed to analyze the requirements of A. T. & T.'s operation to determine which inventions and discoveries should be adopted, how they should be applied, and when.

An important objective is to select the most worthwhile projects for de-

velopment and to make the most effective use of limited development manpower.

Another important function of this group is to anticipate future communication requirements of A. T. & T. customers, including the services, the airlines and the Civil Aeronautics Administration in order to guide BTL's developmental efforts. Since both humans and dollars play a prominent role in communications, they must be factored into any systems engineering analysis.

Most important, any new developments must either be compatible with the characteristics of the existing system or must be introduced on an evolutionary basis.

The end product of systems engineering activities at BTL usually is a plan or program, not hardware. The men who perform these tasks must be broad in experience and background, with extensive knowledge of BTL's development and research activities and the specific problems of A. T. & T.'s operating companies. The men are mostly engineers by training.

BTL's Systems Engineering area is divided into three general departments:

- **Systems Studies,** a long-range planning group headed by M. L. Almquist.
- **Transmission & Outside Plant Engineering,** under P. W. Blye.
- **Switching & Special Systems Engineering,** headed by F. J. Singer.

The last group is the one which is studying civil aviation communication requirements under Air Navigation Development Board sponsorship. The planning for United Air Lines' VHF ground-air communications network was carried out by the Transmission & Outside Plant Engineering Department.

ANDB Program

Since 1952, Bell Telephone Laboratories has had a small group studying civil aviation communications and already has come up with some interim recommendations, although the program is continuing.

There are many similarities and some differences between this problem and the ones Systems Engineering usually tackles. As in most A. T. & T. studies, the objective was to find ways to improve the efficiency of the present system if possible, to recommend changes that could be introduced in evolutionary fashion without disrupting existing service, and to achieve this improvement at minimum expense.

Such a study involved an analysis of existing facilities, operational techniques and utilization, or load factor. It also involved studies of the human operators—in this case the pilot and traffic controller—who always figure prominently in any analysis of a communications problem, according to Kenneth Van Wynen who heads the project.

To make the study, BTL people first had to familiarize themselves with traffic control procedures and problems, to determine the relationship between communications and traffic flow. To assist in this education process, BTL hired Charles Stanton, former CAA Administrator. In the course of its studies BTL found that individual traffic controllers, like human telephone operators, vary widely in their traffic handling ability.

Out of these studies, for example, has come a BTL report that recommends adoption of a ground-air data link. Since data link messages must be transmitted from a ground data link station to traffic control centers, BTL recommended a time division, moderately slow rate data link (650 bits/second) which could use existing telephone lines and would not require installation of more expensive facilities.

Changes Often Operational

BTL's long experience in solving the problems of its parent companies has taught the systems engineers that the best solution to a problem may come from operational changes rather than the addition or modification of equipment. In seeking solutions to the air

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communications problem the systems engineering group found itself analyzing traffic control operating procedures.

One of BTL's current ANDB projects calls for a system engineering study and recommendation for providing an integrated system of communications which will provide voice, data link, facsimile, and transmission of radar and other pictorial data.

Studies to date emphasize that some aviation communication channels are badly overloaded while others have relatively low utilization. This suggests the possibility of using techniques developed for telephone exchanges to share the load among all available channels and thereby raise utilization of existing facilities.

The systems engineering group also is working with CAA's Technical Development Center to develop techniques to permit automatic storage and call-out of aircraft flight plan data and for a speedy high-volume weather distribution teletype system.

Military Systems Groups

Within recent months Bell Telephone Laboratories has divided its military systems activities at Whippany into two groups, each headed by a vice president: R. R. Hough and W. C. Tinus. Practically all of the work at Whippany is under direct military contract, approximately 25% for Navy and the rest split almost evenly between Air Force and Army.

Hough's area of responsibility encompasses these three general departments:

- **Guided Missile Development,** headed by L. W. Morrison.
- **Military Systems Development,** under J. P. Molnar.
- **Military Engineering,** under J. M. West.

As prime contractor for the Nike anti-aircraft missile system, BTL is a major power in the missile business. Yet in some ways it is unique among missile manufacturers, Hough points out.

BTL has no desire to expand its share of the missile business. In fact it has been forced to do an increasing amount of subcontracting to handle the expanding requirements of its existing missile programs.

Another notable difference is that BTL makes its own missile experts, bringing them up through the ranks, Morrison says. The laboratories do not engage in the mad recruiting race characteristic of many other missile makers. BTL recruiting takes place primarily on the nation's campuses.

This tends to give its military engineering groups a stability not often found in other defense contractors. The laboratories lose less than four per-

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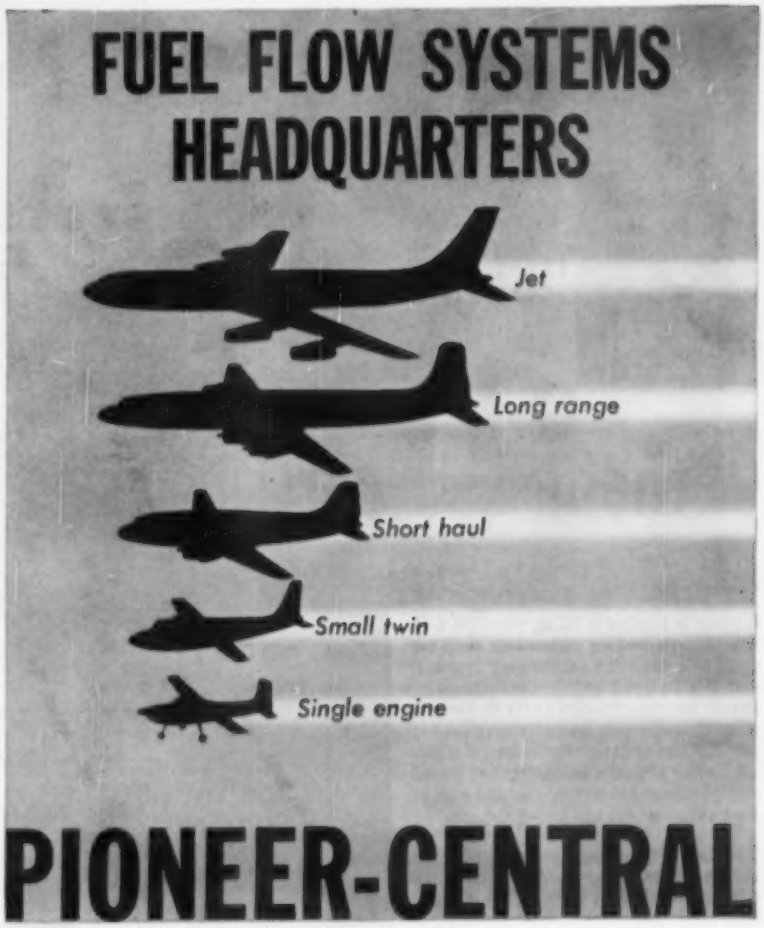

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cent of their scientists each year, compared to an average of 10-15% for the rest of the avionics industry.

Military systems engineers in BTL usually have considerable breadth of experience within the laboratories, which makes it easier to shift them to new programs. It also tends to smooth working relations between different groups and departments, Morrison believes, because they share a common BTL heritage and experience.

BTL's Work on Nike

Douglas Aircraft Co. is a sub-contractor to Western Electric and BTL on the Nike. Hough and Morrison emphasize that the marriage has been both a happy and a successful one. One reason is that Douglas' philosophy coincides with that of BTL: each prefers to operate in its own specialized field and has no desire to invade the other's.

The Nike program has so far proved to be a "solid program," without the peaks and valleys that have plagued other missile programs, Hough points out.

He expects it will be a continuing program which will see the introduction of new and improved techniques, and he does not expect any tapering off in the foreseeable future. He adds that Bell Laboratories plans to stay in the missile field.

Morrison's department now has about 125 engineers on the Nike program—modest for a program of this scope, even though the workload is down from earlier peaks. But Morrison points out that there is considerable supporting effort elsewhere in the laboratories.

Another military systems group, reporting to Tinus, is located at Western Electric's North Carolina plant where the Nike guidance systems are manufactured.

This group performs the familiar liaison function to smooth the transition from development and design into manufacturing.

30,000 Nike 'Firings'

Because the Nike is an expensive one-shot affair, it would be extremely costly to fire enough to enable designers to gather the data they need to determine how the missile will perform against a variety of targets and under a variety of conditions.

BTL designed and built a Nike missile system simulator which fully simulates a Nike attack. It has "flown" 30,000 simulated Nike missions and can handle 150 per day. To assure that the simulator performs the Nike mission realistically and accurately, BTL uses data from actual Nike runs made at White Sands to correlate and calibrate it.

Now the device can be used to simu-

late attacks that would be impossible to make—for example, a Mach 2 target flying at 100,000 feet—and thus to predict Nike performance against targets of the future.

Another useful application is in determining the best maneuver that one of our bombers should make to get away from an enemy version of the Nike.

An equally important simulator task is to provide speedy evaluation of the effects of proposed Nike changes or modifications on its performance under a wide range of conditions. Such data can be obtained with the simulator in a small fraction of the time and cost, that would be required if actual missions had to be run.

Ballistic Missile Guidance

One of the major activities in Molnar's Military Development department is development of guidance systems for two of the Air Force's three ballistic missiles.

Hough will say only that these guidance system efforts employ some of the techniques developed in the Nike program.

Balance of this department's work is devoted to development of new ferroelectric devices, delay lines, piezo-electric devices and transformers. About half of this work is under military sponsorship, the remainder for A. T. & T. needs.

One program is a fundamental study of quartz as a material to better understand its characteristics. A typical question is: why does synthetic quartz have a lower "Q" than natural quartz? Army Signal Corps is sponsoring the quartz study.

Another, under USAF sponsorship, is aimed at developing miniature, high-temperature transformers. Knowledge and techniques coming out of this program will be made available to transformer manufacturers. Still another program sponsored by the Signal Corps involved a study of components that had failed in military equipments to establish basic cause of failure and to recommend remedial measures to component manufacturers.

Projects for Signal Corps, USAF

The Military Systems Engineering Department, headed by J. M. West, in some ways resembles a military version of the civil systems engineering activity.

One current contract, for example, is a study for the Signal Corps to determine the kind of communications system which will be needed by a highly mobile army organized for nuclear warfare.

Another recently completed program for Rome Air Development Center was a study of the USAF's present global

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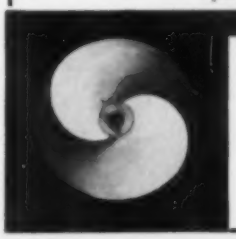

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Aerothermodynamic Staff members discuss heat flux during reentry of a hypersonic vehicle. Left to right: J. I. Osborne, aerodynamics; R. G. Wilson, thermodynamic research; W. E. Brandt, thermodynamic analysis; Dr. L. H. Wilson, Thermodynamic Section head.

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communication facilities and its requirements. Still another program in this department involves development of plans for integrating and interconnecting a number of Nike installations. Another group is working with Lincoln Laboratory and Western Electric to develop techniques for testing the complex SAGE sub-sectors.

Exploratory Development

The department's activities also include exploratory developments. One was Tradic, an all-transistor airborne digital computer developed under Air Force sponsorship. Another program involves development of new types of radars.

The second Military Systems Vice Presidential Area at Whippany, headed by W. C. Tinus, consists of two general departments:

• **Military Electronics Development,** headed by W. H. C. Higgins, has several major defense programs, including a ground-air data link system for Navy and a bombing-navigation system for USAF which employs digital computer techniques developed in the Tradic program.

The department also is contributing to the Nike and ballistic missile guidance programs.

• **Military Design Engineering,** under E. H. Bedell, provides a number of services to all departments at Whippany. These include specialized design services, drafting, preparation of instruction books and environmental testing.

BTL group stationed at Western Electric's North Carolina manufacturing facility also is a part of this department.

Civil, Military Benefits

Any group the size and stature of Bell Telephone Laboratories is bound to make important defense contributions. But there is a more subtle contribution that stems from the fact that BTL is part of the American Telephone & Telegraph Co.

Because of this relationship, BTL brings to its defense tasks a keen awareness of the importance of reliability and the price that must be paid to achieve it. Furthermore it brings to its defense tasks long experience in dealing with very complex systems and in weighing added complexity against its cost in initial expenditure and upkeep.

Although BTL's defense projects have benefited from its normal civil pursuits, it has not been a one-way street.

Unquestionably these defense programs have spurred and accelerated BTL's efforts in fields which will be reflected in improved communication services to A. T. & T. customers. ■

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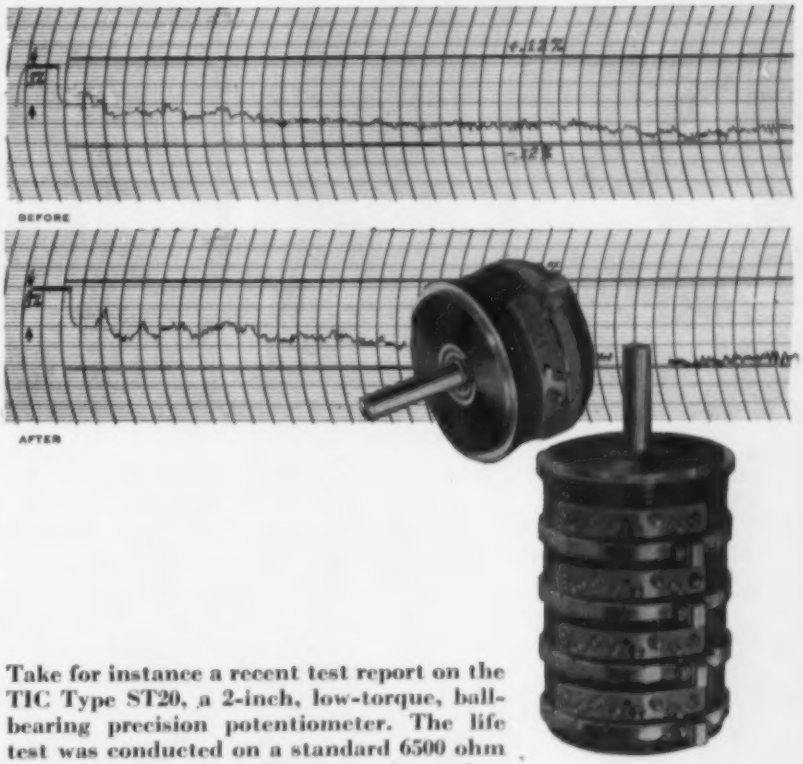

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Some of the change in linearity after the life cycling can be attributed to change in effective resolution due to contact wear. Other results from the life test indicate less than 100 ohm equivalent noise resistance except for one spot, where it was less than 1000 ohms. The 1000 ohm spot was of such short duration that the linearity recording did not pick it up. Test Summary: The ST20 will perform with only infinitesimal degradation for over 700,000 cycles. If it's long life *at full precision performance*, that you want, specify precision potentiometers by TIC.

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SEVEN STORY Vanguard test stand and check-out tool at Baltimore. New facilities also include 200-ft. sq. aircraft test hangar.

Martin's Research Is Broad, Varied

By Evert Clark

Middle River, Md.—Martin Aircraft Co. does research and development on a number of levels and for a variety of reasons—including a conviction that basic research must be encouraged and increased as a national resource, and a belief that it can be done on a profitable business basis.

Research and development at Martin breaks down traditionally into fundamental—done by its special subsidiary, Research Institute for Advanced Study, Inc.—and applied, which is done by almost every department in the parent company's Engineering Division.

Martin has become increasingly diversified as to location, as well as in product lines. In addition to the long-established Martin-Baltimore, new divisions have been created within the past year and a half at Denver, Colo., and in Orlando, Fla.

Denver Division's primary mission is development of the second USAF intercontinental ballistic missile, the Titan. With this as its task, the division's efforts will be largely those of applied research and development for the next several years.

Orlando Division was created primarily for the manufacture of the Army surface-to-surface missile, Lacrosse. Therefore its mission so far as research and development is concerned will lie also in the applied area, but with enough fundamental research as is necessary to fill some of the gaps in development of future weapon systems.

The overriding philosophy throughout the company is that research and development is everybody's business. What some researchers at Martin call "breakneck technology" has a voracious appetite for new knowledge. Quite often this appetite can neither be satisfied with existing knowledge nor be stalled long enough for the needed bits of information to present themselves in the normal course of discovery.

For this reason, technical sections of the departments in the Engineering Division devote some effort to research and development—much of it for application to problems of the immediate or near future, but some of it aimed well ahead of the need.

Aside from the fundamental work done by RIAS, research and development at Martin are carried on in several different ways organizationally:

• **Building block research.** This is the effort of the technical sections. By and large it is done only where there is a need and no back-up, but there is no attempt to build up a universal capability in all specialities. Instead, work that can be done inside the plane is done, and work that is the particular province of some outside firm is contracted for.

An example of this is found in the

ARMY'S surface-to-surface Lacrosse is manufactured at Martin's Orlando Division.

Electronics Department, which has sections for system design, installation design and equipment design, plus a service section and a program planning staff.

Some development is done on component parts, such as display tubes, but none is done on radio parts. Again, no transistor work is done because others are better prepared in this area—but development of new circuitry might be handled within the department.

Electronics also is fairly typical of the other departments in the amount of effort it puts on research and development—approximately 10% of its personnel and about 10% of its budget.

Martin Sponsors Most Work

Building block research, which takes its name from the fact that it attempts to fill in the blank spaces in the pyramid that represents a weapon system, is sponsored largely by Martin itself.

Breakdown is roughly 30% contract-sponsored by government agencies, 70% by the company.

More than 200 employes of the Engineering Division put most of their effort on this type of research and follow-up development. Total personnel involved is about 6% of the division's work force.

• **Research on a project basis.** Once a Martin design program reaches the stage where a contract has been obtained, it becomes a specific project within the Project Department, and acquires an Operations Manager—becoming almost a company within the company.

Specific examples are the P6M SeaMaster project, TM-61 Matador, B-57 bomber and Vanguard satellite vehicle. Each has a project engineer for research.

Research project engineers, like the project manager, can draw on the services of any of the technical departments for support.

• **Research coordinators** in each department, to guide and draw together the efforts of researchers in their sections.

• **Research and development** coordinating committee. Only about three months old, this committee is expected to assume considerable importance in Martin's structure. Headed by J. J. Saunders, it is made up of the research coordinators from the departments.

The committee defines avenues of research and technical goals in view of the products that Martin anticipates. It also recommends and instigates work in new areas that it feels the company should be investigating, even though specific products are not yet in sight.

In addition to coordinating with representatives from the technical departments, the committee keeps quality control and manufacturing research representatives abreast of advanced

DENVER Division's new $10 million plant is developing Air Force Titan ICBM.

TEST STAND No. 1 for Titan is separated from manufacturing plant by mountain.

DENVER facilities, located in foothills of Rockies, include this cold flow laboratory.

In systems engineering work, it is necessary to bring together a team that includes scientists and engineers of a wide range of technical specialties. In major weapons-systems projects, such teams will include hundreds of scientists and engineers.

But the assembly of a large group of scientists and engineers, no matter how capable they may be individually, does not of itself ensure good systems-engineering performance. The caliber of the project management has a major effect upon its technical accomplishment. It is not easy to coordinate the activities of large numbers of scientists and engineers so as not to stifle their creativeness on the one hand, nor to permit the various development sub-efforts to head toward mutually incompatible objectives on the other.

Of primary importance for good systems management is the philosophy underlying the selection of the supervisory personnel. The head of a technical activity should, first of all, be a competent scientist or engineer. A common mistake – nearly always fatal in systems work – is to fill such positions by non-technical men who have been trained only in management techniques. In the highly complex activities of major systems work, what is required is *technical management*, and of the two words, the word *technical* must never be overlooked.

In the selection of scientists and engineers for technical management, it is essential that the men chosen be broad in their training and approach. Each principal department head, for example, must have a good basic understanding of the technical facts of life of the other departments. When these people get together they need to speak a common language and understand each other's fields, so that proper decisions can be made on the many interrelated problems that come up. The higher the organizational responsibility of a technical manager, the more important this factor becomes.

The Ramo-Wooldridge Corporation is engaged almost entirely in systems work. Because of this, the company has assigned to scientists and engineers more dominant roles in the management and control of the business than is customary or necessary in most industrial organizations.

Scientists and engineers who are experienced in systems engineering work, or who have specialized in certain technical fields but have a broad interest in the interactions between their own specialties and other fields, are invited to explore openings at The Ramo-Wooldridge Corporation in:

Guided Missile Research and Development
Aerodynamics and Propulsion Systems
Communications Systems
Automation and Data Processing
Digital Computers and Control Systems
Airborne Electronic and Control Systems
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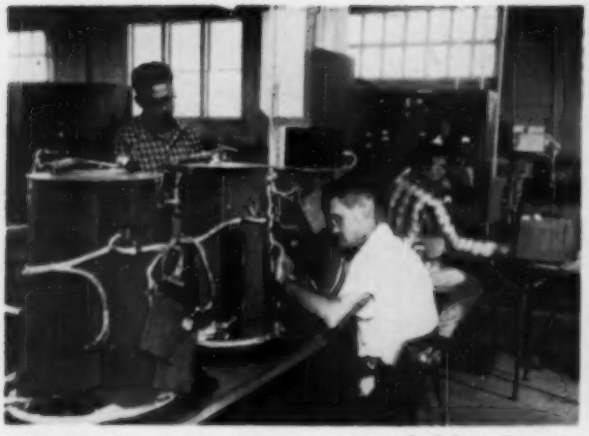


LACROSSE telemetering shelves are inspected, left, tail cone assemblies are riveted in temporary facilities at Orlando.

thinking on technology and products.

Tendency is away from organization by physics and toward organization by systems, although Martin executives feel the two methods always will be mixed.

Martin points out that Navy, perhaps its biggest customer in recent years at least as far as number of products goes, actually has operated with the weapon systems concept longer than Air Force, although with less public emphasis.

With the SeaMaster project, for instance, Martin as weapon system manager bought even the engines, whereas Air Force provided the engines for its first weapon system, the Convair B-58.

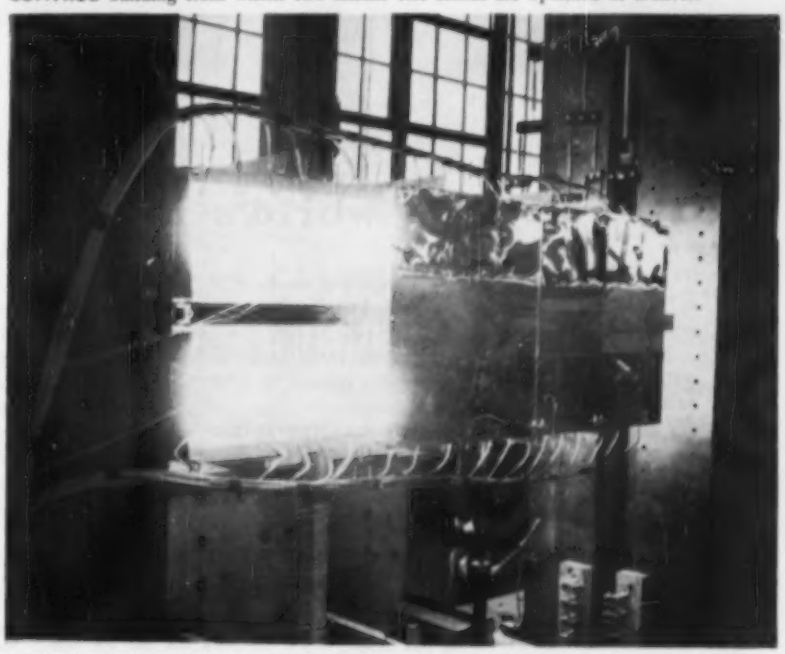
Technical Departments

Technical departments within the Engineering Division form a home base for individual engineers, even when they are assigned to specific projects. They report to their project engineers for the engineering work itself, and to the departments for administrative purposes.

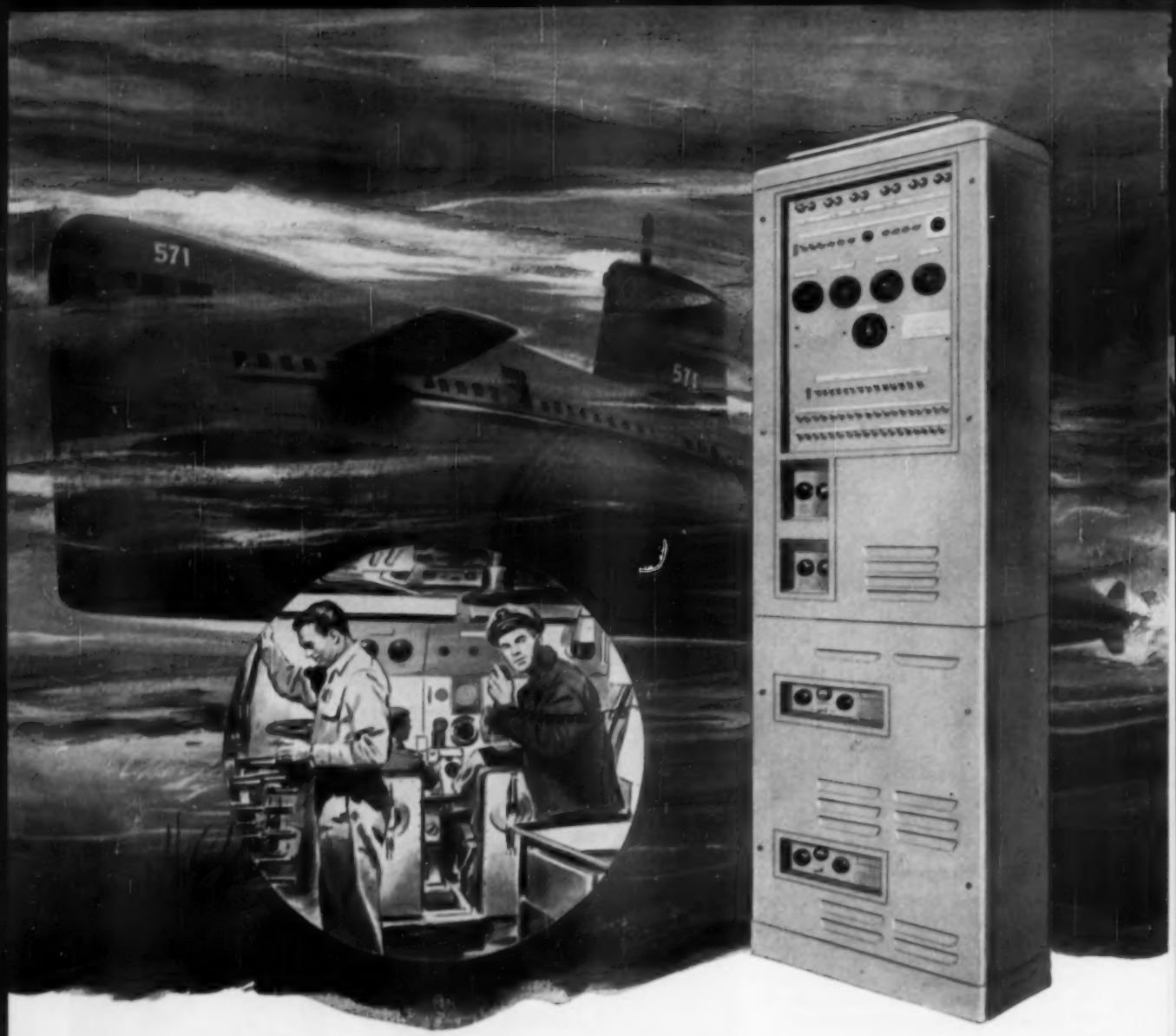
Technical departments and their sections are:

- **Advanced design,** with sections for requirements and plans, weapon system evaluation, Air Force projects, Navy projects, missile projects and air defense projects.
- **Project department,** with sections for the P6M, TM-61, B-57, Ferret, Vanguard and a Special Projects Section.
- **Flight test,** with experimental Flight Test Section, Production Flight Section, Airworthiness Section and a section for control tower and operations.
- **Flight dynamics department.** Sections are aerodynamics, advanced design, hydrodynamics, experimental aerodynamics, propulsion, simulation.
- **Structures.** Sections are structural design, weights, instrumentation, structural test, materials engineering, dynamics, advanced design.
- **Product design.** Sections are airframe

CONTROL building from which two missile test stands are operated at Denver.



RADIANT heating with over 200 kw. output tests construction specimens at Baltimore.



To voice the world's newest submersibles

The shipboard and battle-announcing needs of a submarine pose problems that just "standard" equipment can't meet.

Exceptional ruggedness is required, both to withstand shock and to resist heat, humidity, and salt moisture.

Power must be adequate, yet compressed into the smallest possible space.

Dependability is relative to such factors as cruise distances never before attempted by underwater craft.

An example of products meeting such problems is found in the announcing equipment aboard the atomic-powered *Nautilus* and *Seawolf*, built by our associate division, Electric Boat, and "voiced" by Stromberg-Carlson. Here standard components were re-designed to the special conditions involved. On the *Nautilus*, to date, our equipment has logged more than 60,000 nautical miles without difficulty of any sort.

Similar equipments also serve the land and air arms of our country's military forces and give evidence of equal dependability under the special conditions for which they were designed.

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design, equipment and furnishings, producibility, nuclear systems, human factors, integration, advance design projects, production project, and staff section.

• **Electro-mechanical department** has a technical staff, and servo, mechanical, electrical and armament and ordnance sections.

• **Operational support systems,** with product utilization, electronic support equipment, mechanical and support sections.

• **Design support,** with presentations, engineering facilities, project support, product support, nuclear support and engineering library sections.

• **Electronics,** with a program planning staff, a services section, and three sections which are further subdivided. These are Electronics System Design Section, broken into configuration, system function, analysis; Electronics Installation Design, with nuclear, radio frequency and installation; Electronics Equipment Design, broken down into components, data system, navigation and guidance, and electronic reconnaissance.

Advanced Design Department

Advanced Design Department's mission can be described as putting the "building blocks" of the technical departments together to try to win competitions with them.

The job is to develop ideas far enough to sell them as contracts. Once they become contracts they become projects, acquiring project managers and operations managers, and Advance Design goes to work on something else.

A small percentage of Advanced Design's work is paid for by government research and development contracts. The rest is supported by the company.

Stimuli for the work are:

• **New knowledge,** whether it comes from the research done in the technical departments, from RIAS, or from outside sources, Advanced Design's job is to know about it and apply it.

• **Desire of the customer.** Bulk of the department's studies are done on requests generated by the government. Although few of these are backed by contracts, Martin—like other aircraft companies—has access to long range planning of the services and is encouraged by them to propose ideas for new weapons and weapon systems.

• **Knowledge that could be exploited** if it were in hand. Considerable effort is devoted to finding solutions to long-standing problems. For example, analyses have been carried on for the past year of possible modes of propulsion. Mathematical and theoretical analysis, though a small percentage of the department's total effort, plays a large part in this area.

Advanced design, so far as its exist-

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STANDARD and CUSTOM DESIGNED TIMING MOTORS and DEVICES!

for military and industrial applications. Illustrated are some of these units . . . any can be modified to meet your specific requirements if the basic design is not adequate.

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Long a pioneer in the timing field, The A. W. Haydon Company is prepared to assist you in solving your timing and control problems. When a solution to your problem has been reached, The A. W. Haydon Company is prepared to follow through with production geared to meet your requirements whether a basic timing unit or a highly specialized device is required.

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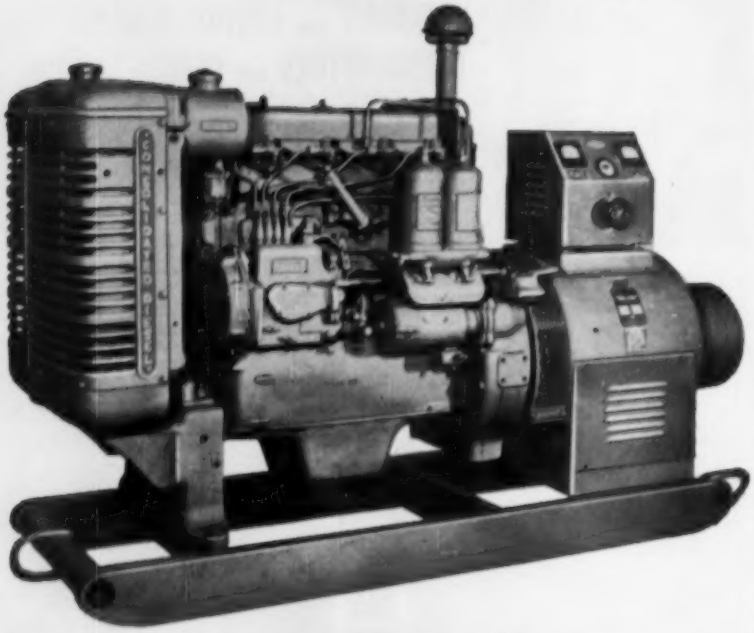

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ence as a separate department goes, sprang from a special group set in 1946 to get into the missile field early.

From a Pilotless Aircraft Section, the group grew into the Advanced Design Department which now has about 350 employes. Early efforts of the section and department were Matador, the first operational USAF guided missile, and Viking, the first successful large research rocket.

Missile programs now embrace all three services.

Advanced Design sees its job as largely one of management, with detailed work coming from the technical departments.

Just as the Engineering Division's philosophy is that research and development is everybody's business, so this department wants everybody to take part in advanced design work.

Heavy traffic of engineers through the department from the other technical departments is one aspect, but another is communications with other parts of the company outside the Engineering Division.

Considerable coordination work is done with quality control, tooling departments, service people, and so on.

Inter-Company Communications

Primary aim of this widespread communication network is to avoid having to "sell" Martin's own new ideas and new projects to the rest of the company. In some aircraft companies, new proposals "come cold out of engineering"—often to get a cold reception in the rest of the plant, Advanced Design officials say.

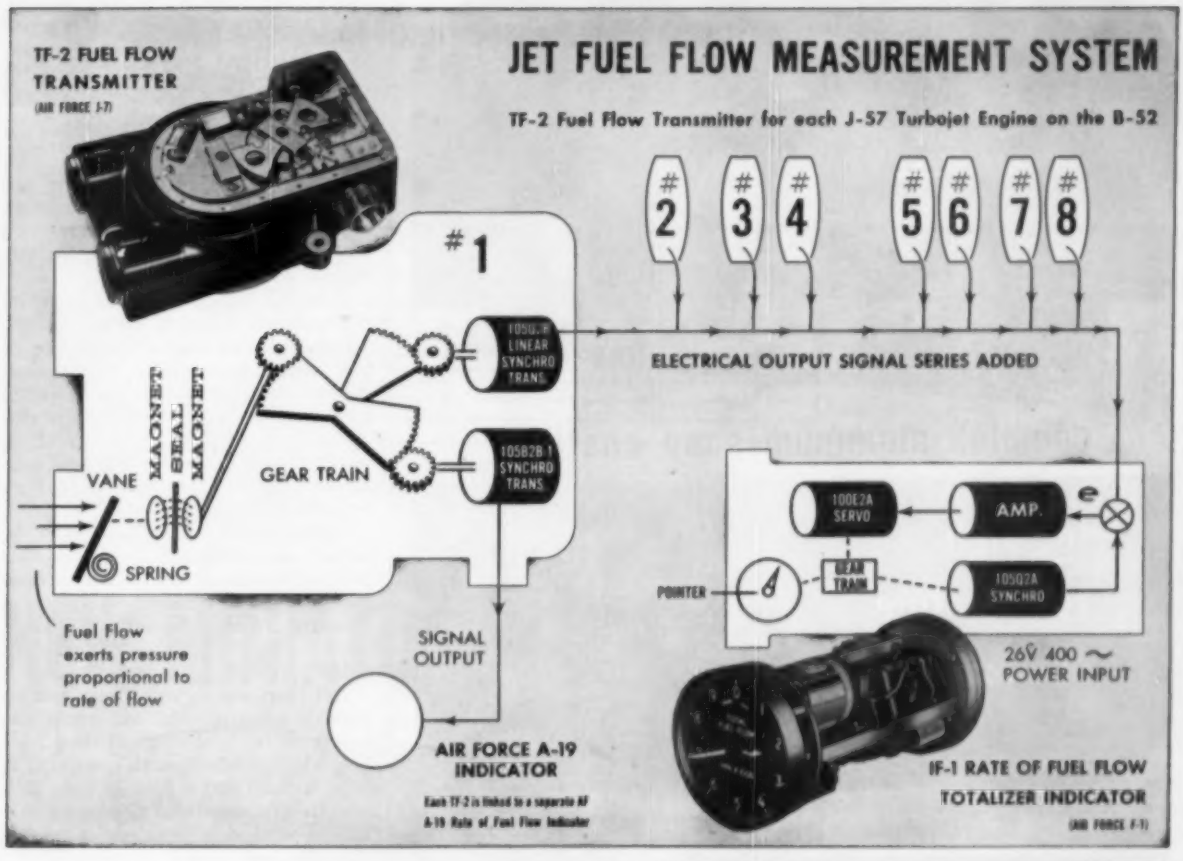
Department philosophy is one of emphasizing solutions to practical weapon system problems in a short period of time, rather than emphasizing what it calls "dreamwork." It does not try to sell 20-year development programs to the services. At the same time, one of its efforts is, according to one section chief, "to make the space ship respectable." The department feels that a good many of the problems of space travel are purely mechanical.

Typical of the department's current areas of interest are:

- **Escape systems.** This is considered of primary importance. Although there is some government sponsorship, the company is supporting most of the work.
- **Cooling and protection** of structures.
- **Overall increase** in airframe and electronics realiability.
- **Delivery of warheads** at very high speeds.

Recently separated from other work in the department to give it more emphasis is air defense, which deals with both aircraft and missiles and covers logistics, ground control, etc.

Martin believes that strategic weapons will soon have reached full cap-



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Is your problem accurate read-out of rates of fuel flow? Consider how Norden-Ketay instrument design simplifies this system for precise measurement of large volumes of fuel to the eight engines of Boeing's new B-52. The IF-1 Indicator, matched with 2 to 8 TF-2 Transmitters, registers up to 100,000 lbs./hr. with extreme accuracy over the entire range.

Rate of fuel flow against a vane actuates a linear synchro transmitter in each TF-2, producing an electrical signal proportional to its angular displacement. The total of the eight synchro signals oppose the voltage from a linear synchro in the IF-1. The difference, or error signal, is the input to the amplifier.

This amplified error signal drives the servo motor, which rotates a gear train positioning the pointer and linear synchro. The synchro, as a feedback device, produces a voltage equal and opposite to the input signal, and nulls the signal at the amplifier input.

Again, the inherent advantages designed into Norden-Ketay instruments have improved system simplicity and reliability.

TF-2 SPECIFICATIONS — Weight 7.0 lbs. max. Range 0 to 12,000 lbs./hr. Accuracy: ±5% approx. Operating temp. range: −55° to +121° C. Altitude: −1,000 to +80,000 ft. Pressure drop less than 3.0 psi. Pressure sealed. Meets MIL-T-7477A (ASG) and MIL-E-5272.

IF-1 SPECIFICATIONS — Weight 2.8 lbs. Range 0 to 100,000 lbs./hr. Accuracy: ±1% approx. of full scale. Altitude: −1,000 to +80,000 ft. Operating temp. range: −55° to +70° C. Response time: 20 seconds. Hermetically sealed. Meets MIL-I-7491A (ASG) and MIL-E-5272.

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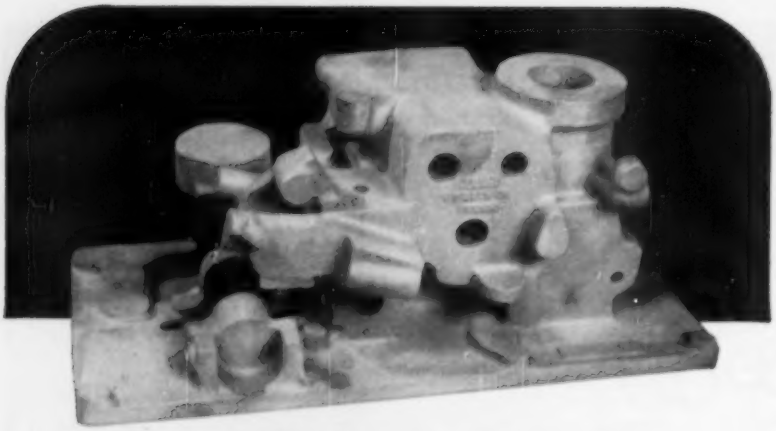
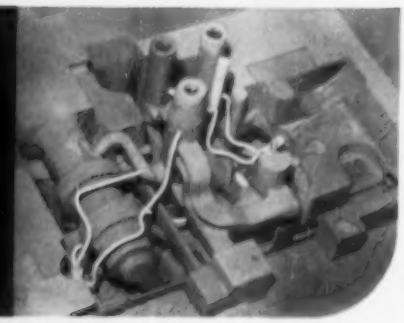


complex aluminum sand casting

for high temperature applications



intricate internal cored passages for above casting

This extremely complex aircraft valve body is currently being sand cast by Rolle in two aluminum alloys . . . 355T6 and 356T6. But as part of a continuing program of casting research, Rolle has also poured the piece with equal success in ZRE1 and A-142. While A-142 does not yet have the acceptance of many other alloys, Rolle is extremely interested in its possibilities in high temperature applications.

The valve body is an ideal test piece for such research. Few castings offer a tougher trial of as-cast properties. The many small diameter passages through the piece demand intricate tube coring as well as the more conventional sand cores. The tubes are removed after casting by a process developed in Rolle's Research Laboratory.

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ability of erasing an enemy's country, and that the potential standoff that will result will invite small, brush-fire wars. The company is putting more emphasis into understanding this type of war and the weapons needed to fight it.

RIAS Concept Is Unique

Unique in the aircraft industry and perhaps throughout the nation's industrial complex is Martin's basic research subsidiary, Research Institute for Advanced Study, Inc.

Potential impact of its philosophy on the national research picture is tremendous. If its basic concepts can be put across successfully, the stature, quality and particularly the scope of basic research will be increased greatly.

Basic idea is that fundamental research can be done on a business basis —the search for new knowledge can be sold competitively.

Applied research—which can be turned much more quickly into production and therefore into dollars—is done by some 45 different foundations, laboratories and companies devoted exclusively to that, and done profitably, if not specifically at a profit.

But there are no such basic research groups, organized on the traditional non-profit or not-for-profit basis followed by applied research groups. The basic research that is done in companies and universities is in a large sense subsidized, and not done on a pay-its-own-way basis.

Some of the reasons for the creation of RIAS, according to Vice President Welcome W. Bender, are:

• **No more great foundations** with almost unlimited endowments, are being established. Tax structures have left the nation with "no millionaires able to build bevatrons any more."

• **No new universities** are being founded. With an increase in population of some 20 million in two decades, there has been almost literally no increase in the number of universities. Although they are doing more sponsored research, both basic and applied, "breakneck technology" uses up the supply from all sources faster than it is being produced. In addition, developmental work is draining off talent from the universities and from government laboratories, with the result that there is great developmental effort with too little new content in it.

• **Conservationist philosophy.** This is a belief that everyone who helps to consume new technology has a responsibility to put back new seeds. Industry, largest consumer of the fruits of technological advances, must help create more advances.

• **Universal support of research.** Since the products of research are benefitting everyone, and since income is spread around considerably more than it once

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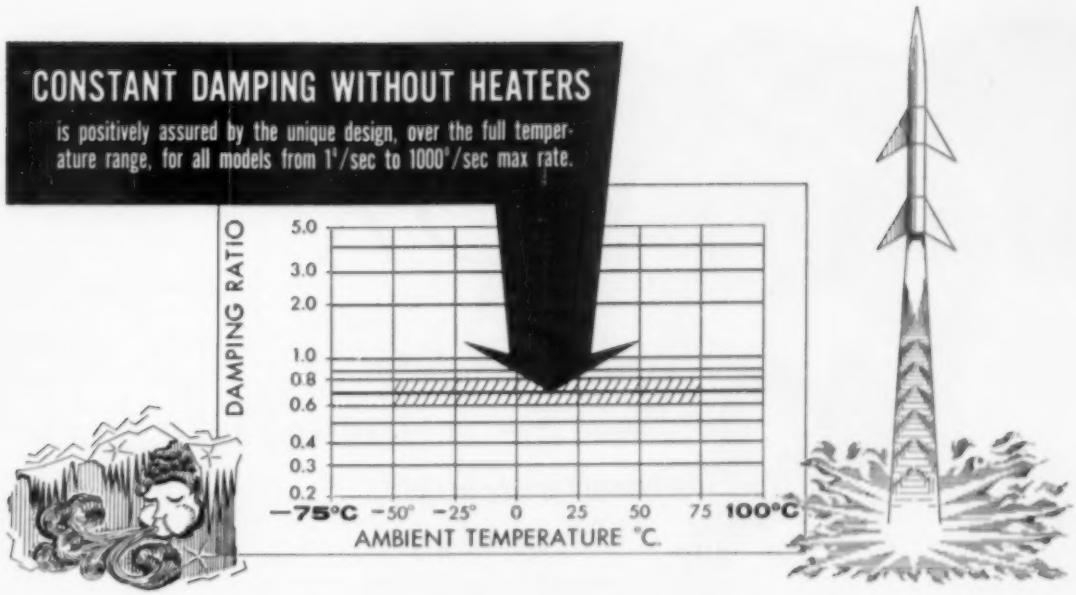
is positively assured by the unique design, over the full temperature range, for all models from 1°/sec to 1000°/sec max rate.



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was, the cost of research should be spread around also. Industry is being called upon by the services to put more and more effort into basic research, but RIAS sees no reason why bankers, farmers, laborers, retail merchants shouldn't do the same.

On these last two points, Martin executives felt that successful operation of a company like RIAS would do two things:

• **Broaden industry's interest** in basic research by proving that research could be self-supporting, in addition to providing indirect benefits.

• **Bring fundamental research** out into the open, emphasizing and encouraging the idea that it is a vital national resource to be supported by government to a much greater degree than it is now, primarily through the National Science Foundation; and to be sponsored wherever possible out from under the direction of the services, since benefits of really fundamental research apply so much more broadly than to weapons alone.

RIAS' Appeal

RIAS "is not interested in product development and not interested in being a charity operation," Bender said.

Its aims, operations, and atmosphere are similar to the Institute for Advanced Studies at Princeton University, except that it engages in experimental science as well as theoretical.

Facilities are modern and adequate. Location now is downtown Baltimore, but RIAS hopes to move shortly to an undisclosed location nearby.

RIAS' appeal as far as the researcher is concerned is an industrial salary coupled with optimum physical, mental and motivational conditions.

It attempts to maintain an academic atmosphere, but the routines of teaching chores, etc., are eliminated. RIAS guarantees independence in selecting work and continuing projects, and encourages lecturing, publication of findings and attendance at professional society meetings.

Its investigations are shaped largely by the researchers it hires. General fields of work are:

• **Physics.** Investigations include extensive work on the general theory of relativity, including field equations and gravitational radiation, effect of acceleration on the rates of natural clocks, etc.

• **Biophysics.** A large effort is being put on photosynthesis.

• **Biochemistry.**

• **Metallurgy,** with emphasis on better undersfanding of the role of imperfections, such as dislocations and vacancies, in relation to the flow and fracture phenomena of metals.

• **Mathematics.**

Laboratory facilities include a full

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J-M Tadpole Firewall Seals *block passage of flame and combustibles between compartments*

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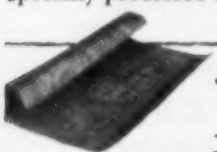
J-M Tadpole Seals are made with a specially processed Inconel wire mesh core. This base is covered with asbestos cloth combined with Neoprene, Silicone, Teflon or other materials to assure top performance within each temperature range. All seals comply with the C.A.A. requirements for flame resistance. Style numbers and temperature limits are as follows: 4132-250 F, 137-350 F, 4134-450 F, 4133-500 F, 4161-600 F, 4381-over 600 F.



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#89 Bomber Cloth flexible firewall fabric saves precious pounds. It is the lightest material of its type, yet withstands the most severe C.A.A. tests.

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Asbestan Cushions give a resilient cushioning with low friction on A.N. clips used for hydraulic lines at temperatures up to 500 F. Specially made of asbestos and Teflon.

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Style No. 924 has a steel mesh core, is aluminum jacketed for temperatures to 850 F, stainless steel jacketed for higher temperatures.

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complement of physical laboratory equipment.

One goal of RIAS is to close the great time gap between basic scientific discovery and its application to engineering problems. Martin felt that this problem, primarily one of communications, could be handled well if the fundamental research operation were set up on a business basis.

A major result is frequent contact between Martin's Engineering Departments and RIAS—with RIAS doing some investigating on contract for the departments, but retaining always the right to say no if it thinks a Martin proposal is applied rather than basic research.

Denver Plant Builds Titan

Martin's Denver Division consists of a recently completed $10.5 million plant 20 miles southwest of the city, in the foothills of the Rockies. Martin holds a $358 million contract for design, fabrication and testing of the Titan ICBM.

This work will be the main effort of Martin-Denver.

Employment will reach 5,000 when the plant, first occupied last February, becomes fully operational.

Main building is a two-story factory, 612 by 246 ft., containing 306,700 sq. ft. of floor space. There also is a two-story administration and engineering building and a one-story cafeteria building.

Test stands are separated from the factory by a mountain, reducing noise and safety problems but keeping test facilities close by.

Since the main plant was completed plans have been announced for three more structures valued at some $2 million—additions to the administration-engineering building and to the cafeteria, and a new engineering laboratory, 240 by 340 ft.

Denver Division is organized by systems rather than specialties, and engineering is the controlling item. Chief engineer is second in command to the division general manager.

Orlando Division, now in temporary facilities, will occupy four buildings nine miles southwest of the city, totalling 488,000 sq. ft.

Mission is research, development and manufacture of "newer weapons in such fields as guided missiles, electronics, nucleonics and small weapons systems."

Major product announced so far is Lacrosse, 20-ft. solid-fuel Army missile for close and general support.

Martin's vice president for engineering, George S. Trimble, said no definite line is drawn on where the company will do what work, even though it now consists of three geographically separated divisions. ■

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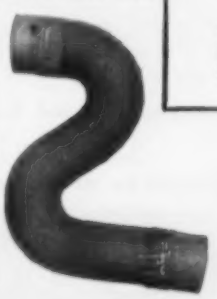
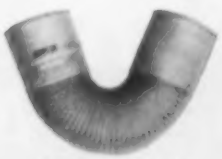
Compressed Air Starter Ducts

Horizontal Stabilizer Anti-icing Duct Pressure Seal Boot



Radome Anti-icing Outlet Duct

Radome Anti-icing Duct Pressure Seal Boot



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Flexflyte is an exceptionally lightweight ducting that is highly resistant to abrasion, vibration and flame and impervious to temperatures from minus 120°F. to plus 650°F. It will handle internal working pressures up to 70 psi and external working pressures up to 15 psig depending on type. Designed for use with ventilating, defrosting and de-icing systems, Flexflyte will take tight turns at any point up to 180° without buckling. No elbows or special fittings are required for installation.

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Flexflyte can be engineered for a variety of unusual applications in many special shapes, fabrics, coatings, connections, lengths and diameters. Our special Silicone Department, working with automated machines, is prepared to meet the most exacting requirements for silicone ducting.

To find out how Flexible can solve your aircraft ducting problems, write us, outlining your requirements. Our engineers will be glad to put their experience to work for you. Write Dept. 206.

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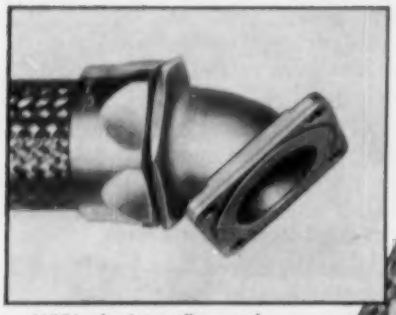
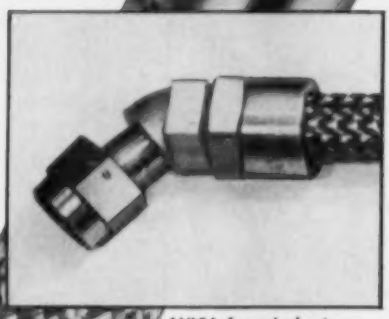
AVICA flexible tubing assembly with special elbow and swivel flange



AVICA aluminum elbow and swivel flange with 2 inch stainless steel flexible tubing.

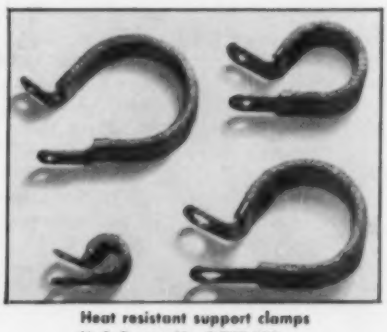


AVICA forged aluminum elbow end fitting with ½ inch stainless flexible tubing.

AVICA mechanically attached end fitting with swivel nut.

AVICA special flange end fitting.

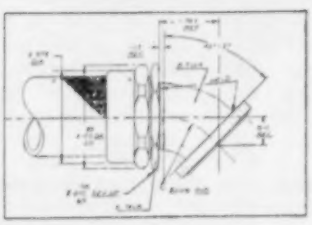
AVICA Stainless steel flexible assembly with aluminum elbows and fittings.



Heat resistant support clamps U. S. Patent No. 2,709,558.

AVICA stainless steel flexible assemblies with mechanically attached end fittings and swivel flanges in stainless steel or aluminum are suitable for fuel, oil, hot air and other fluid systems. They can be supplied to customers design in all I.D. sizes from ¼" to 4".

Let AVICA handle your rigid and flexible line problems.



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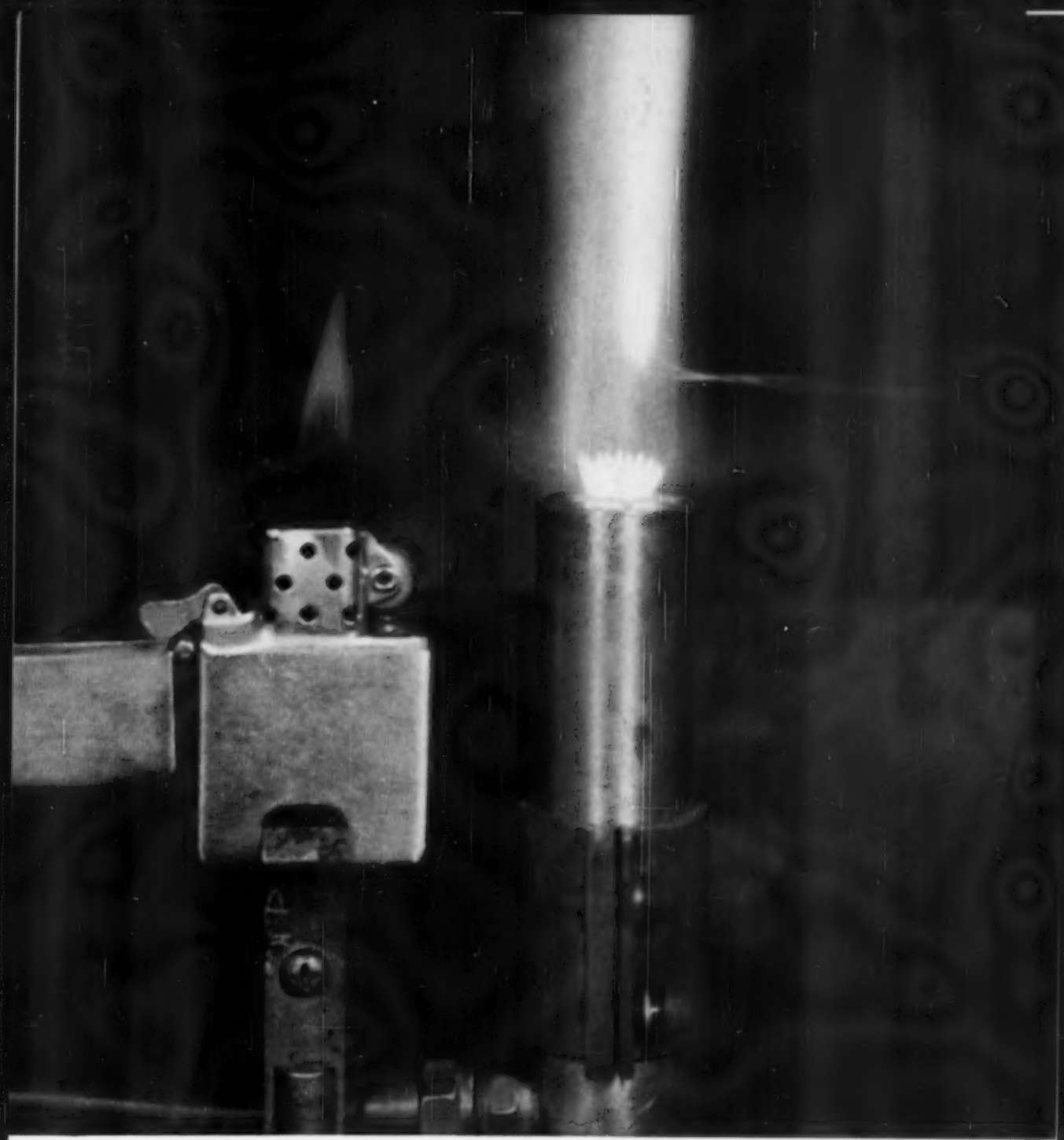
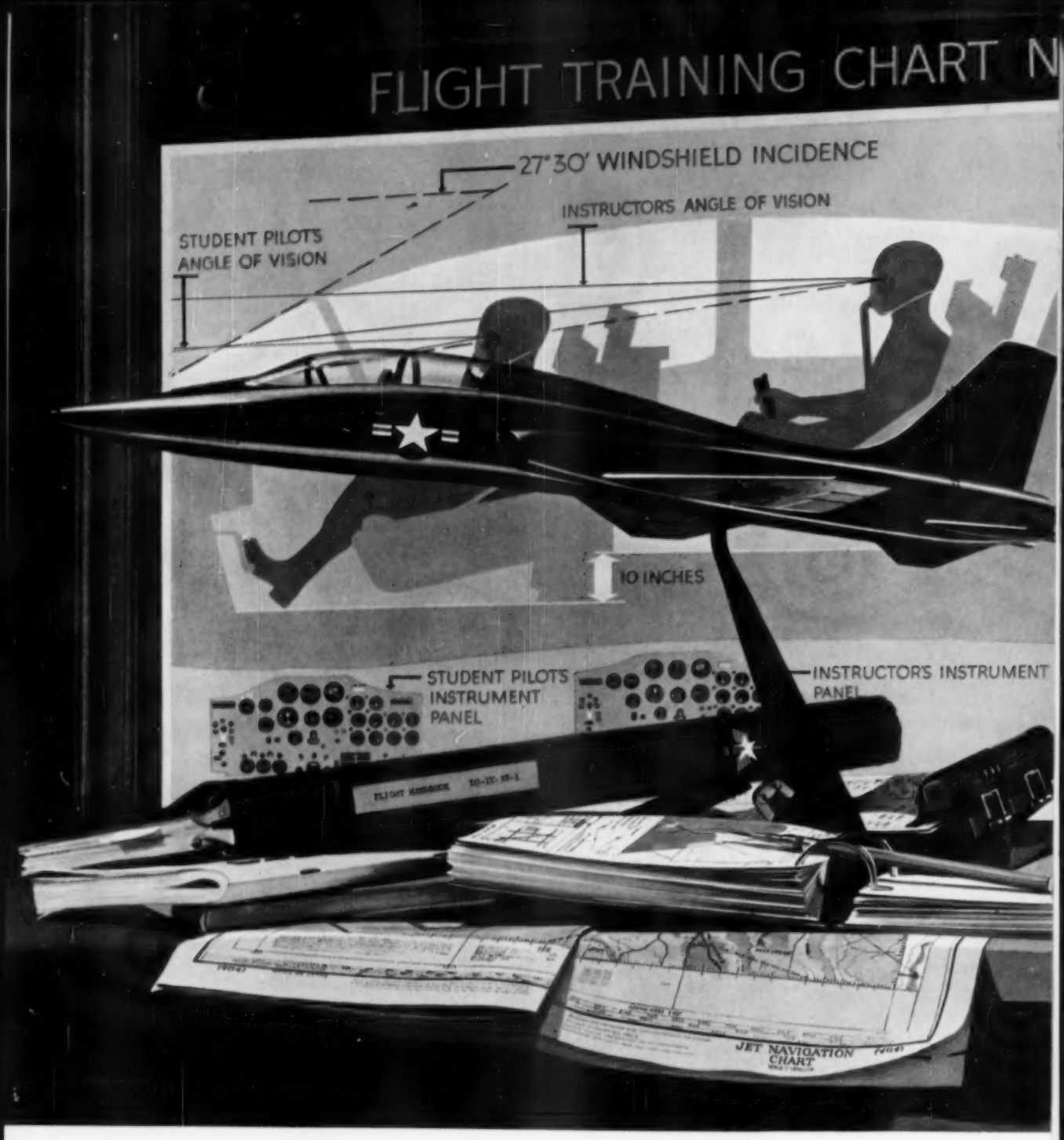


CYNAGON-OXYGEN flame boils nickel-iron wire to vapor at 4800K at Temple University Research Institute.

Universities



SIMPLE ARITHMETIC– It costs approximately ten thousand dollars to send a student through college today, but more than ten times that amount to give a young man the superlative training that he must receive to become an Air Force pilot. A saving in either expense would be welcome to most Americans. Northrop Aircraft is ***doing something*** about reduction of national defense costs by applying "dollar engineering" to planning and production of new weapon systems. Latest Northrop achievement is its supersonic T-38 jet trainer, a simple, lightweight airplane capable of using any improved airport. Costing less to produce, fuel and maintain than other airplanes with comparable performance, the T-38 can save American taxpayers hundreds of millions of dollars in pilot training. This T-38 jet trainer... and the Snark SM-62, world's first intercontinental guided missile... are noteworthy developments of the budget-minded research, engineering and production teams at Northrop.

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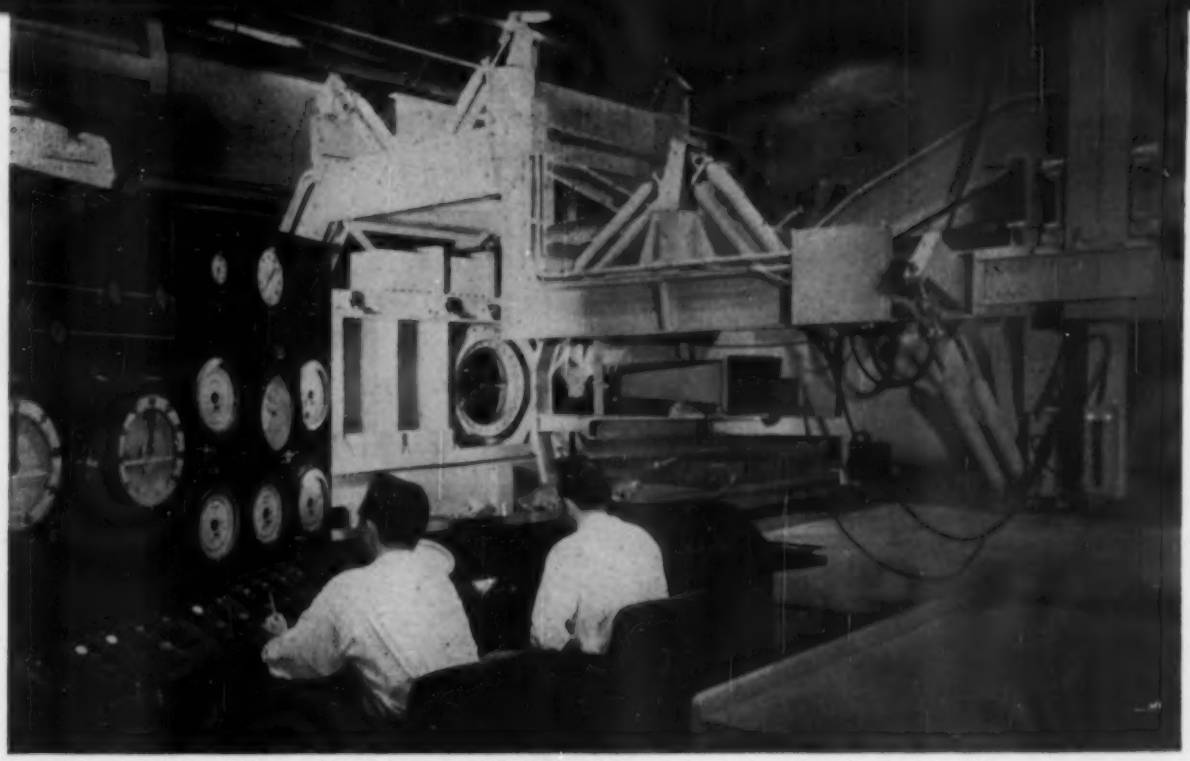
Builders of the First Intercontinental Guided Missile



SUPERSONIC wind tunnel at Massachusetts Institute of Technology has control instrumentation close by test section.

Research Plays Large Role at MIT

Cambridge—Sponsored research plays a lusty role in the educational program at Massachusetts Institute of Technology.

Prior to World War II, sponsored research was an insignificant factor. Wartime impetus of military demands for better scientific tools has carried through the postwar decade. This year the Department of Defense is spending $43 million on research projects including Lincoln Laboratory at MIT.

Demands for More Research

One reason for the large volume of sponsored research is the insistence by the defense agencies that MIT undertake their programs. The volume would be much higher if the Institute accepted everything pushed at it. Academic leaders, like Dean C. Richard Soderberg of the School of Engineering, in their soul searching, wonder if they have been selective enough, if they have not given into the demands of the military too freely.

They also regret the lack of a broad internally supported research program. So far, the trustees have been leery of the permanence of the sponsored research and afraid that some day there would be the heavy cost if the government agencies cut back heavily on their research spending.

Education still is king with research as its servitor. But the servitor could usurp the crown unless the Institute continues to take great care.

Close to 50% of the time of the aeronautical engineering faculty, for example, is spent on sponsored research. All but two or three of the 28 professors in the department spend 20% or more of their time in research, 14 spend 50% or more, and five spend 75% or more.

Of 1956 academic expenses totalling about $460,000, sponsored research funds paid for $150,000. Tuition income covered slightly less.

Yearly budget for sponsored research in the Aeronautical Engineering Department runs about $11.9 million, including $9.6 million in the Instrumentation Laboratory and $1,125,000 in the Naval Supersonic Laboratory.

Advantages of Research Projects

Despite this preponderance of research money, the Institute policy demands that all research projects promise significant contributions to the educational program. Nearly all faculty members are unanimous in citing these gains from sponsored research:

- **Job support** for promising graduate students. Before the war, when research funds were very scarce, there were only 13 graduate students; now there are 110. Over half receive at least partial financial support as research assistants.
- **Good research areas** for graduate theses. The annual report on activities of the department says, "from the standpoint of theses assistance, sponsored research gave more or less direct help to substantially all the men who received advanced degrees." Continually, professors refer to the "live research" and "rich new areas" which sponsored research opens up to graduate students.
- **Faculty contact** with latest scientific advances. Sponsored research keeps the staff "chasing live or real rabbits," is a favorite expression. Sponsored research allows the faculty to keep up and ahead. This draws and keeps the best men to the faculty. It also provides new material to keep the curriculum alive.

From Project to Classroom

Example of how this works is the field of instrumentation and automatic control. Original research began in World War II. In the postwar period, the subject entered the graduate curriculum. Now it is down in the undergraduate curriculum. In fact, the undergraduate aeronautical engineer may complete his course with a specialization in automatic control rather than aerodynamics, structures or propulsion.

Other examples are courses in flutter now given in the graduate school but which seniors may take as electives; in missiles design—an option now available—and in inertial guidance which will be available for the first time next year.

Participation in sponsored research is

TEST SECTIONS for supersonic wind tunnel are 3 by 3 ft. for range from Mach 1.5 to 2.5, 18 by 18 in. to Mach 4.3.

voluntary. There also is no direct financial inducement—professors are not paid extra.

A higher level of academic salaries at MIT probably reflects the heavy research program.

Negotiations are conducted directly between the professor and the sponsor. The professor is responsible for accepting the work statement from sponsor.

These two factors are considered a necessary and also adequate check against involvement in "pot boiler" research. A professor does not have to undertake research projects—and if he does he is the one who accepts or passes on the work order.

On the other hand, this could become a subtle pressure on the professor to undertake sponsored research. It's too early to tell if professors are being rated on the basis of their research undertakings; but certainly the professor who has under his wing projects which are providing jobs and theses subjects for graduate students automatically has a big plus on his rating card.

This, of course, is the most skeptical way of looking at the program. Against this should be considered the fact that sponsored research, if not the only source, is certainly the easiest source of funds for supporting research which will help a professor progress in his chosen field.

So far, it appears that MIT's Aeronautical Engineering Department has policed itself well. How well can best be judged by reviewing the research programs within the department.

Before surveying these, however, it must be noted that there is a vast amount of research applicable to aviation in other sections of MIT. Some of these, such as Research Laboratory in Electronics, Servomechanisms Laboratory, Lincoln Laboratory and other sections in the School of Engineering will be covered later in this story.

Aeronautical Engineering

Aeronautical Engineering Department has organized its sponsored research activities into seven sections:

• **Instrumentation Laboratory.** This is the largest single activity, with a budget of nearly $10 million and a staff of over 700. Its primary interests are guidance and control problems for projectiles, rockets, missiles and manned vehicles. Increasing emphasis is being placed on missile guidance. The laboratory is most noted for what it probably has been least able to talk about—inertial navigation and guidance systems.

Other important research projects have included long range submerged navigation system being produced by Sperry, all-maneuver flight control system for jet aircraft being made by Lear, fighter-bomber fire control by A. C. Spark Plug, bomber defense system using similar principles being tested by Emerson Electric, and design of miniature and better components for guidance systems.

• **Naval Supersonic Laboratory.** This is a development test facility built during World War II with Navy funds and operated by the Institute under an agreement with the Navy. With a budget of over $1 million and a staff of over 100, this laboratory puts about one-third of its effort on analytical and research problems.

Present facility consists of a continuous flow supersonic wind tunnel with a range from Mach 1.5 to 4.3. Up to Mach 2.5 test section is 3 by 3 ft. Above that is 18 by 18 in. Last year's operations totaled about 2,100 hours of test time.

Of this, all but 15 to 20% was for industry. A major industrial user of the tunnel is Boeing.

Design of a hypersonic wind tunnel is underway. First runs will reach Mach 5 to 6.

Eventual goal is Mach 9. Size will be approximately 6 by 6 in.

Focus of the research is on supersonic and hypersonic aerodynamics with emphasis on the problems of aerodynamic heating and heat transfer. New areas will include ionization problems, magneto aerodynamics and transpiration cooling.

• **Aeroelastic and Structures Research Laboratory.** Research projects in this laboratory run about $600,000 per year. Subjects covered include high temperature effects on structural strength, low cycle and high stress fatigue, blast and thermal loading, procedures for including temperature effects in structural analysis of elastic wings, shock and impact, supersonic flutter, gust loads and aeroelasticity effects on helicopter blades. Recent proposals have been made for projects in aerothermoelas-

ticity and in establishing procedures for structural analysis and influence of coefficients of low aspect wings which exhibit non-linear properties.

• **Aerophysics Research Group.** Activities of this group trace back a little over six years to a request from USAF to undertake study of airplane control particularly in the transonic speed range. They early discovered the inertial cross-coupling effects that later plagued the F-100 and other transonic and supersonic aircraft. From these projects came designs for auto-pilots for transonic speed ranges.

This research has been concluded. Now two programs are concerned with improved mathematical methods for extracting stability derivatives from transonic and supersonic flight test data using digital computing equipment and with measurement of static and dynamic stability derivatives of bluff bomb shapes.

Trajectory analysis begun for long range missiles, including the intercontinental ballistic missile are now being continued to other types of vehicles. One type would be hypersonic gliders.

Cruise Control for B-52

Still another type of research has been in cruise control with the development of instrumentation for one type and design for another. Programming control started out with all the knowledge of the engine and the airplane and evolves a prediction of the most economical settings to use throughout the mission. Simple instrumentation to enable the pilot to do this as a practical matter has been built and will be flight tested this fall on the B-52.

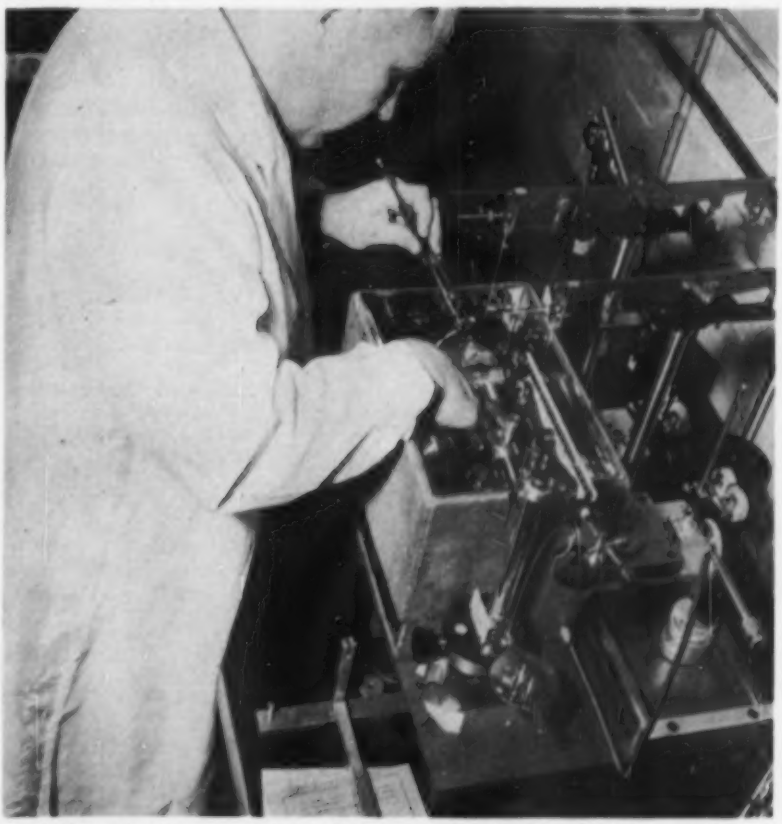
Optimalizing control seeks to provide a system which will automatically provide cruise control by setting the throttle so that the airplane will fly at highest speed per unit of fuel consumed.

Working independently of knowledge about airplane and engine, the equipment will measure speed and fuel flow rate, compute and examine the ratio and find the optimal throttle settings. System will now be built for a turboprop installation.

• **Fluid Dynamics Research Group.** Volume of the research in this group is less than $75,000 annually. Areas of prime interest have been unsteady aerodynamics, boundary layer problems at high speeds, boundary layer interactions with shock waves, stability and control at transonic speeds, dynamics of oscillating shock waves.

• **Gas Turbine Laboratory.** This laboratory does no classified research. It functions with financial support from four engine manufacturers—General Electric, Westinghouse, Curtiss-Wright and Allison Division of General Mo-

FLOATED gyroscope undergoes dynamic testing on two-axis-of-freedom scoresby.



BALANCING floated gyroscope to required accuracy is painstaking, delicate operation.

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tors. From time to time it has had some support from National Advisory Committee for Aeronautics or Office of Naval Research.

It takes all of the money contributed for research and puts it in one pot and decides that it can do certain things that it believes are currently significant.

Among recent contributions is a new theory of rotating stall. Stall passes from one turbine blade to the next. The results help establish lower limits on the weights of gas turbine powerplants.

Current projects are examining behavior of boundary layers in gas turbines, particularly the behavior of skewed flow. Boundary layer separation is always skewed, flow altering as the wall is approached with the angles of skew often being large.

The companies which support the gas turbine laboratory program receive in return for their contribution first sight of the project results. General publication is withheld for one year. They also have an opportunity to get in and see who the students in the laboratory are.

• **Wright Brothers Wind Tunnel.** This facility consists of three elements: blowdown transonic tunnel, blowdown supersonic tunnel and the original continuous low speed tunnel. The low speed tunnel is primarily used for commercial testing. Major projects in the transonic and supersonic sections include measurement of static and dynamic properties of bluff bodies at speeds up to Mach 2.

Lincoln Laboratory

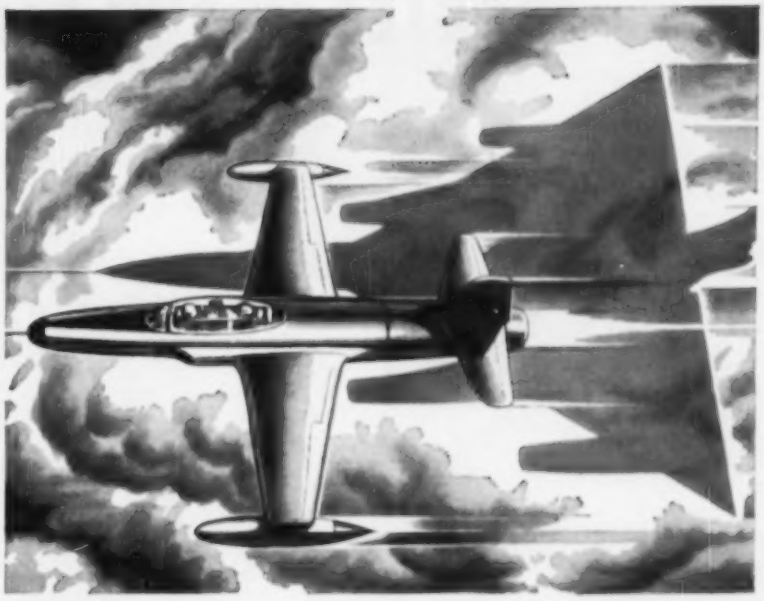
Well over one-half of the $46 million which the Department of Defense will spend at MIT this year will go to the Lincoln Laboratory at Lexington some miles away. Lincoln's primary responsibility is the development and evaluation of the SAGE air defense system.

Search now is on to provide improved components for computers, radar and communication systems. This has led to a concentrated basic and applied research program in solid state physics, principally in semiconductors and ferrites and related magnetic materials.

Semiconductor research breaks down into applications, fundamental measurements of all possible semiconductor materials and search for new materials. Applications consist primarily of introducing new fast switching diodes for computers.

Measurement research began with cyclotron reasonance work and has led to new techniques by which magnetic fields of several hundred thousand gauss are reached.

An interesting and unexpected



THE F-94 CASTS A

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Months before the Convair B-58 supersonic bomber took to the air, its handling characteristics had been successfully simulated by C.A.L. on a totally different airplane.

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This project is typical of the 160 varied research projects currently active at C.A.L. — stimulating, technically challenging, and professionally significant. Our research program is unusually broad in scope, encompassing such areas as Aerodynamics, Propulsion, Aeroelasticity, Wind Tunnel Research, Flight Research, Aircraft Design and Missile Systems. This broad program, coupled with our policy of assigning each staff member in accordance with his individual abilities and interests, makes it possible for us to offer outstanding employment opportunities to capable and imaginative men.

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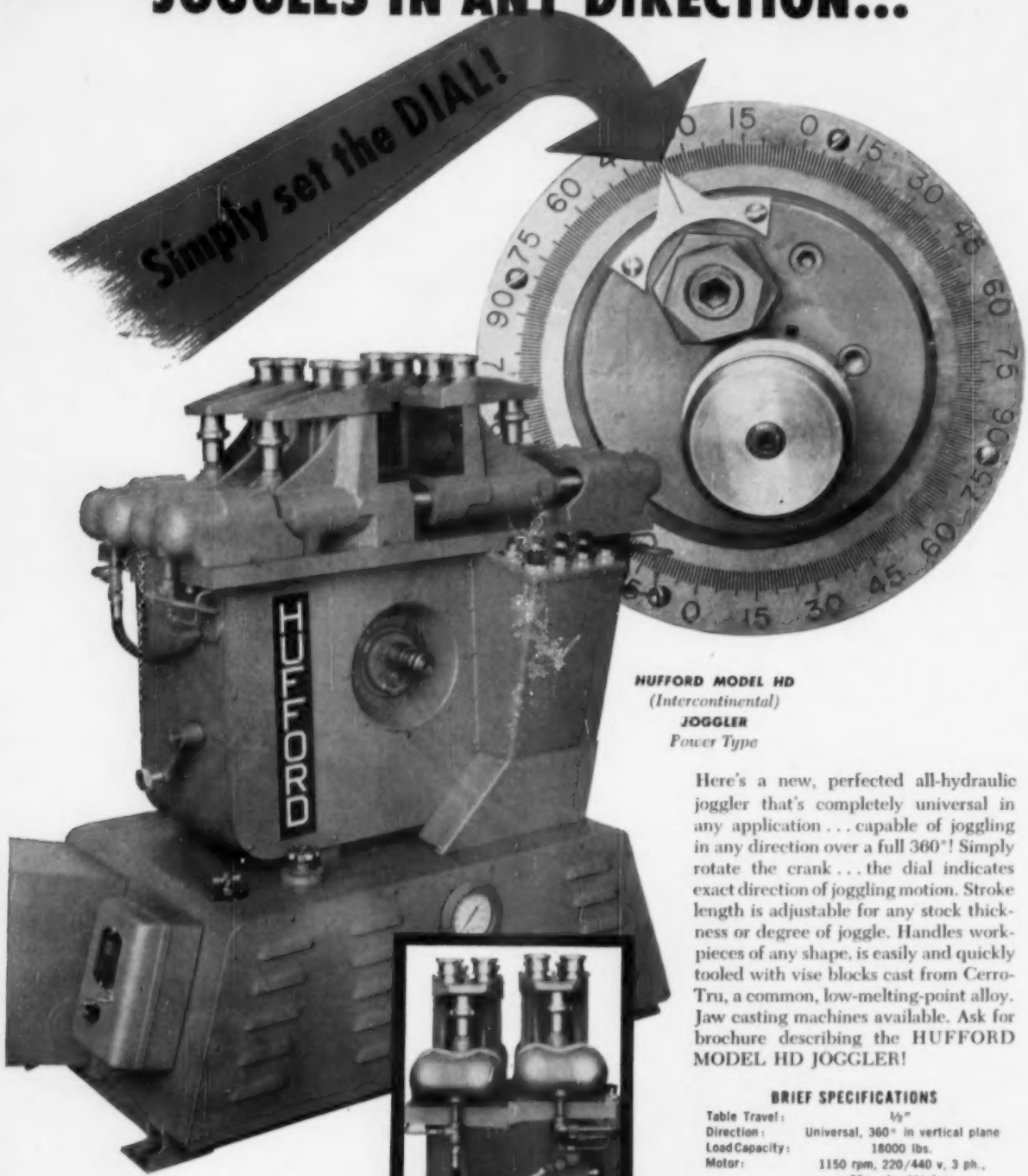

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Here's a new, perfected all-hydraulic joggler that's completely universal in any application . . . capable of joggling in any direction over a full 360°! Simply rotate the crank . . . the dial indicates exact direction of joggling motion. Stroke length is adjustable for any stock thickness or degree of joggle. Handles workpieces of any shape, is easily and quickly tooled with vise blocks cast from Cerro-Tru, a common, low-melting-point alloy. Jaw casting machines available. Ask for brochure describing the HUFFORD MODEL HD JOGGLER!

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Table Travel:	½"
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Load Capacity:	18000 lbs.
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The Hufford Joggler is built in two identical halves along a vertical centerline . . . one ram is stationary, one slidable. Each ram is equipped with its own individual hydraulically-actuated vise. The moving ram slides along a straight line which is adjustable by a front crank to any angle in a vertical plane. Direction of ram motion thus covers a full circle, can be varied to any degree.

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result of the measurement research may be major breakthroughs in infrared. Use of infrared detectors has led the solid state researchers into important basic research on IR and accumulation of data in what had been the "no-man's land between short IR and long IR.

So important do laboratory personnel consider the fundamental knowledge gained that they predict the laboratory will shortly have a lot of "bread and butter" work in infrared.

Work in ferrites is aimed at microwave applications and improvement in basic measurements. Ferrites have possibilities as oscillators or amplifiers much like Masers.

Lincoln Laboratory projects are taking a look at what fails in the systems required in SAGE and seeking how to improve it. This has led to broad areas of unexplored basic research and indirectly is opening new areas for exploration like infrared.

Servomechanisms Laboratory's research programs evolve around a triumvirate—control, instrumentation and data processing. It is particularly interested in the integration of these elements into a system or a process control, like its numerical-control for milling machine, operational flight trainers for the F-104, techniques for testing airborne fire control systems.

It continually searches for better transducers and new components for radar, computers and other electronic equipment.

One important current area is modernization of radar techniques which until recently have not been much different than those of World War II.

Another interest has been energy conversion problems, as applied to aircraft this has meant how to supply electrical energy to the rest of the aircraft systems.

Electronic Research

An outgrowth of the wartime Radiation Laboratory, the Research Laboratory of Electronics is an interdepartmental unit jointly sponsored by Departments of Physics and Electrical Engineering. Within its sprawling organization there is a wide range of electronic and associated research, both basic and applied.

Areas include information theory and statistical communication theory, solid state physics, physical electronics, microwave electronics, microwave tubes, microwave theory, microwave spectroscopy, microwave gaseous discharges, nuclear magnetic resonance, noise in electron devices, frequency modulation, circuit theory, transistor circuits, atomic beams, process analysis and synthesis, network synthesis, speech and analysis and mechanical translation, communications biophysics, neurophysiology and processing and new methods of transmitting information.

Interplay of basic with applied research is strong. Basic research provides new techniques and ideas for application. Applied research uncovers new problems to taunt the basic researchers.

Among the many products of applied basic research at RLE are special purpose computers, high-power magnetrons, transistor circuits, missile guidance systems, new or improved microwave tubes, quantum mechanical amplifiers like versitron klystron amplifiers.

RLE has no core program. But all of its major interests are related to the general processes in communication of information: what information is, what part must be communicated, how to communicate it, improvement of equipment for communicating and generation of energy to communicate.

Neurophysiology may sound out of place in an electronics laboratory. But analysis of the human and animal sensory systems benefits from the measure tools and computing techniques available in the Electronics Laboratory. In return the makers of man-made communication systems gain from knowing more about how the more complex animal communication systems work.

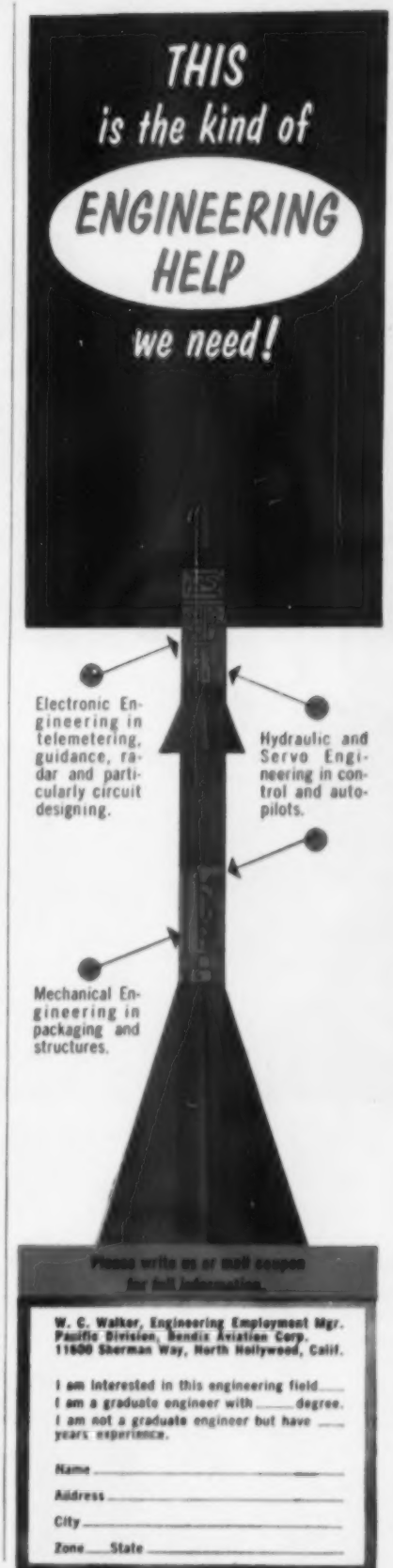
Mechanical Engineering

Research which promises significant help in the design of nuclear powerplants and in cooling surfaces of hypersonic aircraft is being done on heat transfer in the Mechanical Engineering Department.

Experiments and analytical corelation of heat transfer data in previously unexplored areas has shown exceedingly high transfer rates. Heat exchangers with transfer rates of 5,000,000 Btu. per hour, for example, are considered possible.

Present research is investigating the little known phenomenon of boiling, heat transfer of various fluids at supercritical pressures, heat transfer in noncircular pipes and heat transfer performance of plates oscillating parallel to the airflow.

MIT plays a major role in the Institute for Defense Analyses, an independent corporation sponsored by five universities. Its purpose is to provide the Weapon Systems Evaluation Group of the Department of Defense with surveys, analyses and evaluations of weapons systems, new equipment, military problems, new tactical doctrines, technical aspects of strategic planning, actual combat reports and field exercises. Its goal is to determine how weapons and weapon systems can be most effectively employed. Its assignments originate with the Joint Chiefs of Staff, assistant secretary for research and engineering or on IDA's own initiative. ■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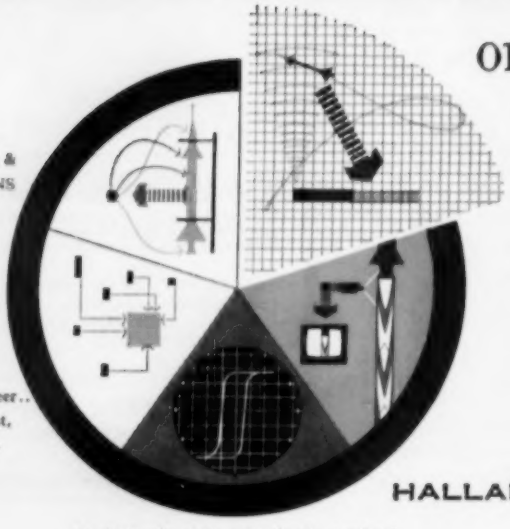

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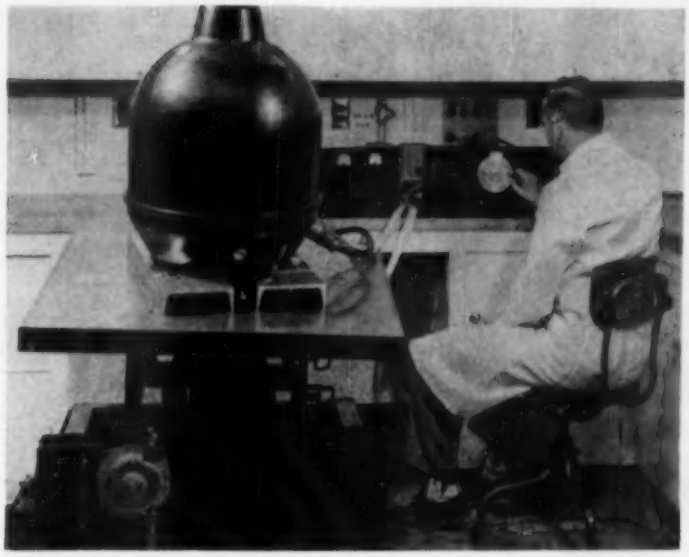

ALL-INERTIAL platform guidance system developed by JPL undergoes test.

PROTOTYPE of semi-automatic missile launcher.

CalTech Eases Air Research Burden

By Irving Stone

Pasadena, Calif.—Contribution that an educational institution can make to ease the research and development burden imposed by fast-changing requirements for missiles and aircraft is underscored at California Institute of Technology in three key facilities:

• **Jet Propulsion Laboratory,** which originates and develops primary missile systems, conducts fundamental research in physical sciences for immediate and future application in weapon system programs, and performs feasibility and evaluation studies in the fields of missiles and components. JPL, a government-owned facility, is operated by CalTech under contracts, principally with Army Ordnance Corps.

• **Guggenheim Aeronautical Laboratory,** in effect CalTech's aeronautical department, providing advanced training for graduate students and conducting intensive research, using staff and students.

Research is supported in part by CalTech and very substantially by various government agencies such as National Advisory Committee for Aeronautics, Office of Naval Research, Air Force Office of Scientific Research, Army Office of Ordnance Research, and Office of the Chief of Ordnance; and National Science Foundation.

• **Southern California Cooperative Wind Tunnel,** managed and operated by CalTech for its joint owners—Douglas Aircraft Co., Inc.; Convair Division of General Dynamics Corp.; Lockheed Aircraft Corp.; McDonnell Aircraft Corp.; and North American Aviation, Inc.

JPL's overall research and development is done by three main departments:

• **Aerodynamics and Propellants.**

• **Design and Powerplants.**

• **Guidance and Electronics.**

The aerodynamic department performs experimental high-speed tunnel tests for guided missile and supersonic aircraft projects for Army Ordnance and USAF contractors. Tunnel development testing has included these projects:

• **Hawk, Honest John,** Nike and Corporal missiles (Army Ordnance).

• **Navaho and Falcon** missiles, Convair

CORPORAL missile, developed by JPL, is placed on firing pad by erector-launcher.

Link Simulators — rehearsal for reality

The Martin TM-61 Matador, deadly ground-to-ground tactical missile of the USAF, already is standing guard over Free Europe's Eastern frontiers. And with the help of a Link radar signal simulator for the Matador, the potent weapon soon will be controlled by the world's best-trained missile guidance crews.

The Link simulator, which the Air Force recently incorporated into its state-side training programs, serves as a "stand-in" for the expensive Matador during simulated training missions. Using their own operational missile control equipment, guidance crews can direct the make-believe Matador from launching to a direct hit on an "enemy" installation . . . and the simulated mission is just as realistic as an actual one.

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B-58, and Marquardt ramjet for Boeing Bomarc missile (USAF).

Tunnel facilities include two supersonic units. One, with a 12 by 12-in. test section, operates up to Mach 4. Another, operating up to Mach 5, has an 18 by 20-in. test section. Third tunnel, with a speed range of Mach 5.5 to 8.5, is scheduled for operation by the end of the year. Test section will be 21 in. square.

This new hypersonic facility will be used for missile development test for Army Ordnance and Air Force, and will include work in the intercontinental and intermediate range ballistic missile categories.

Boundary Layer, Fuels Studied

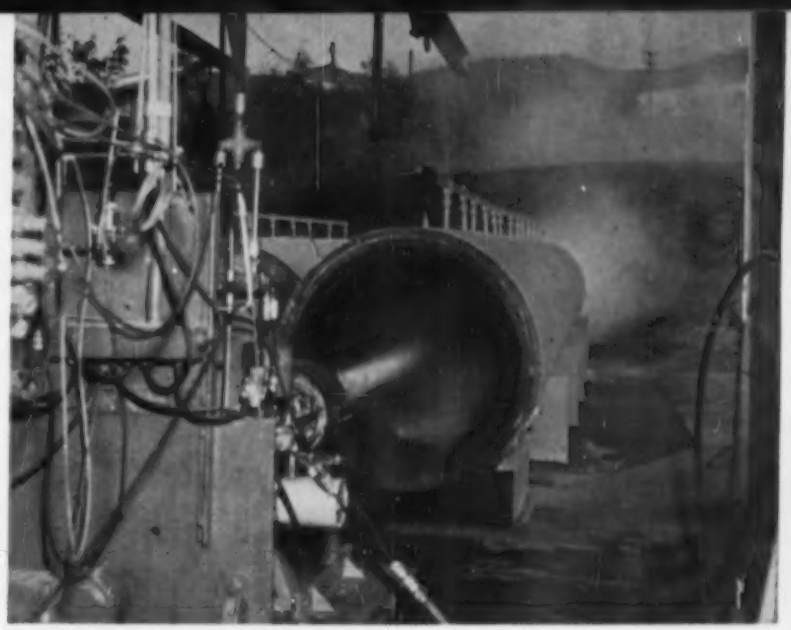
A second aerodynamic activity is to conduct JPL-originated basic research. The new hypersonic tunnel will be used to advance this work. It is scheduled for study of dissociation in boundary layer flow and its effect on heat transfer at very high speeds. Results will be applicable to reentry problems associated with the ICBM and IRBM.

Other basic aerodynamic research includes transition from laminar to turbulent flow at high speeds—another crucial condition affecting missile and aircraft performance and heat transfer.

Air-fuel combustion research, another activity of the Aerodynamics and Propellants Department, includes studies of the mechanism of flame holding and its relation to combustion of air-breathing engines such as ramjets and turbojets. General stability of the combustion process is still another field of investigation.

Combustion research also covers fields of liquid- and solid-propellant rocket engines.

Propellants Group does research and development in the category of solid propellant grains. It operates a basic, general chemistry section and another for research leading to development and synthesizing of new resins, oxidizers and fuels aimed at creating new solid propellants of the composite type.



SMALL liquid rockets are tested in JPL cells. Final tests are at White Sands, Edwards AFB.

It also has a Solid Rockets Section for process development of these new formulations and testing in small rocket motors developed at JPL.

Facilities used by the Propellant Group include installations for mixing, casting and curing solid propellant formulations for JPL research, development and testing; test cells for firing small rocket motors, and laboratories for determining physical properties of solid propellant formulations. For tensile testing of grains, JPL has developed a strain rate tester which applies loads at variable high rates.

Design and Powerplants Department's Design Division is concerned with missiles and components. Activities generally cover two areas:

- **Design of specific missiles** assigned to JPL for development. One example is the Sergeant surface-to-surface missile being developed for Army Ordnance. One other missile, a new project, also is under design and development.
- **Scientific research and systems studies.** Basic research is being conducted in missile materials, with emphasis on properties at very high temperatures. Aim is to obtain data on both short and long duration loading and temperatures. Last year, this division obtained stress-strain data on graphite at temperatures as high as 5,000F.

Another category of basic research in the materials area is the mechanics of failure. Under study are physical properties of single crystals.

Facilities for materials research in-

MODEL of F-100 is mounted on sting strut in Cooperative Tunnel.

THIN-WALL vessel is tested to destruction to learn tolerance.

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Typical of the significant contributions by GPE companies are Librascope's computers and anti-submarine devices . . . GPL's automatic bombing and self-contained navigation system for the Martin Seamaster . . . Griscom-Russell distillation equipment on every class of ship including nuclear powered craft. An indication of Askania's, Kearfott's and Link Aviation's involvement is given in the adjoining column.

Many GPE Group products serve vital defense needs today. The scientific advances they embody will one day benefit everyone.

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praenutius futuri

"Portrait of The Future" is the well-chosen motto of this submarine. States U. S. Naval Institute Proceedings: "The *Albacore* will long be remembered as the pioneer design for flying under water." *Albacore's* revolutionary piloting technique was conceived and produced by Askania, a GPE company.

Link Aviation provides still another glimpse into the future with its F-11-F Flight Simulator in which pilots of the supersonic Tiger *pre-experience* flight conditions and maneuvers, "log" priceless familiarization time. Also "shipping out" with the Navy Air Arm is Kearfott, providing 400-cycle components for both planes and guided missiles.

The coordinated resources of the companies of the GPE Group, so effective in anticipating and meeting the needs of the Navy, serve with equal effectiveness other fields such as:

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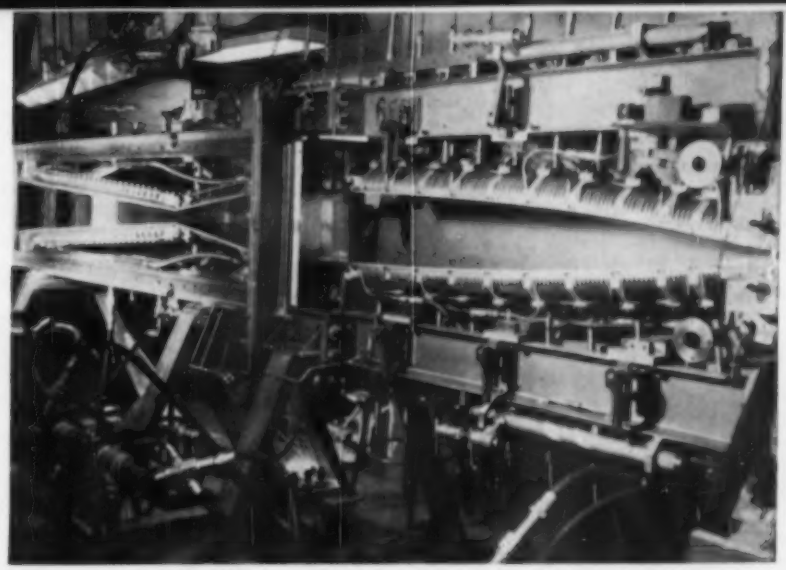


SCALE model of Mach 8.5 tunnel to be operated by Jet Propulsion Laboratory next year.

clude furnaces, electron microscopes, mass spectrometers and, in some cases, specially designed equipment such as the high-temperature tester developed at JPL for the 5,000F tests.

This equipment consists of a vacuum chamber, tensile tester, large-power supply and optical instruments for measuring strain and temperature.

Another facility is a small rolling mill for making billets of special alloys.

Under systems studies, Design Division contributes preliminary estimates of missile and missile component configurations (size and weight) and method of operation. Types of propulsion systems are chosen, aerodynamic shapes are fixed and preliminary structural design is detailed.

High-Energy Fuels

Liquid Propulsion Systems Division of Design and Powerplants Department is concerned primarily with liquid propellant chemistry research, combustion research and rocket motor development. JPL has pioneered propulsion systems using storable liquid propellants and is continuing its research program in the field of high-energy fuels for missiles and rockets.

One goal of this high-energy fuel research is the design of combustion chambers, injectors, and pumping systems for realization of the high performance theoretically available in the new propellants, with the result that overall propulsion system size may be reduced.

Typical problem associated with this research is determination of heat transfer characteristics of the new propellants in relation to regenerative cooling. Pioneer studies in this area have been done at JPL.

Research by JPL's Guidance and Electronics Department has resulted in the development of the Microlock communications system, a solution to the problem of transmitting radio waves very great distances with exceedingly small amounts of power.

Now being used by JPL in some of its missile projects, the Microlock system could be adapted for communication to a satellite such as Vanguard,

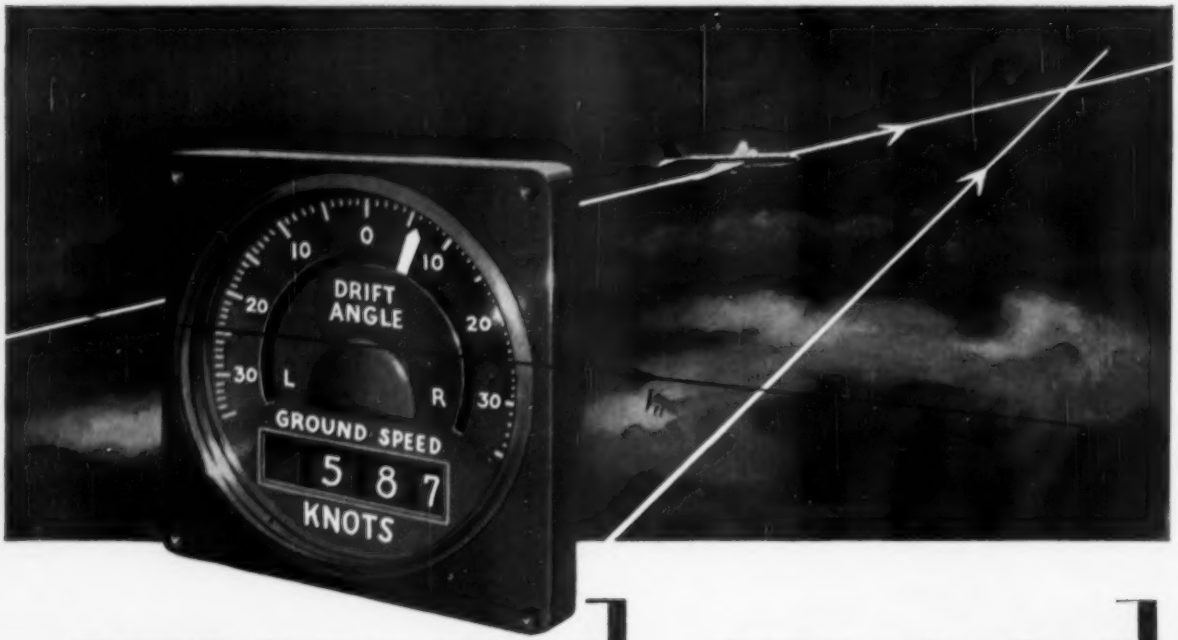
STRESS distribution pattern in photoelastic model of fuselage in Guggenheim study.

One of GPL's ground speed and drift angle measuring equipments, AN/APN-81, provides basic input information to computers which tell Air Force WB-50s exactly where they are every flight second.

GPL auto-navigators give an instantaneous and continuous display: Ground Speed and Drift Angle; Wind Speed and Direction; Longitude and Latitude; Shortest Course-To-Destination; Steering Signal To Pilot (or autopilot).

The systems were developed for the Air Force (WADC). They are the result of an achievement comparable in magnitude to the breaking of the sound barrier: GPL's harnessing of the Doppler-effect to air navigation.

The benefits of these GPL systems extend to every area of flight. Their vast potential has just begun to be explored. Already, air lines awaiting delivery of sleek, high speed jet liners are anticipating availability of the equipment and counting on it for safe, direct and economical global operation.



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which is using the Minitrack system developed by Naval Research Laboratory.

The department's Components Development Group studies design and application of electronic units for specific missiles.

One of the group's major contributions has been development of a technique for packaging electronic devices to withstand extreme vibration environment encountered in missiles. Essentially a method of creating an extremely rigid chassis with many of the components mounted in recesses, the technique has attracted attention of many avionic manufacturers.

Facilities for the Components Development Group includes an environmental test laboratory particularly well fitted for vibration testing. Equipment includes 2,500-lb.-force shake tester, which can be driven by an electronic amplifier so that checks can be made under conditions of vibration similar to that experienced in missiles.

Developing Instrumentation

Instrumentation Division develops new types of equipment needed for JPL's research programs, provides digital and analog computers for staff use, and assists in devising new computing techniques.

A new development of the division is a multi-pressure measuring system for supersonic wind tunnels, which provides checks on 100 pressures during tunnel runs. Pressures are automatically converted into electrical signals in digital form, which can be used directly for digital computation or presented in tabular form.

The department's Systems Engineering Division integrates guidance components into an effective working system. It also operates a Field Test Section for missile test programs at White Sands Proving Ground and Patrick AFB. To obtain data on problems associated with missiles in severe environments, JPL personnel have visited Ft. Churchill, Canada, and have observed field trials such as Operation Sagebrush held in Louisiana last year.

During its research and development work, JPL keeps its eye on the important aspect of production, so that when development is complete, knowledge may be transferred to the contractor to ease the transition phase.

Potential production contractor is brought into the picture very early in the development stage. Essentially he is a laboratory subcontractor at this point, obtaining an understanding of the system to facilitate transition to production. JPL's Military and Industrial Services Section serves as liaison between the laboratory, the industry and the military.

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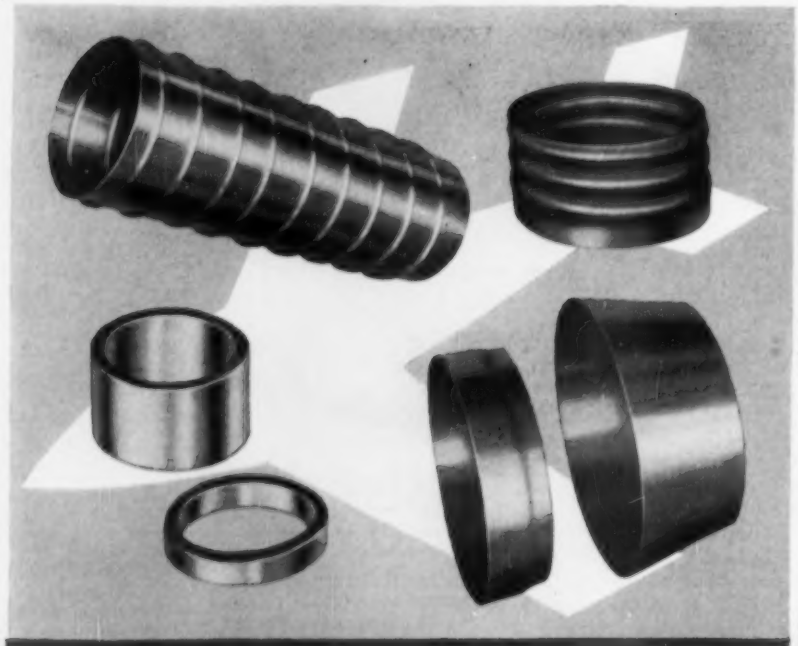

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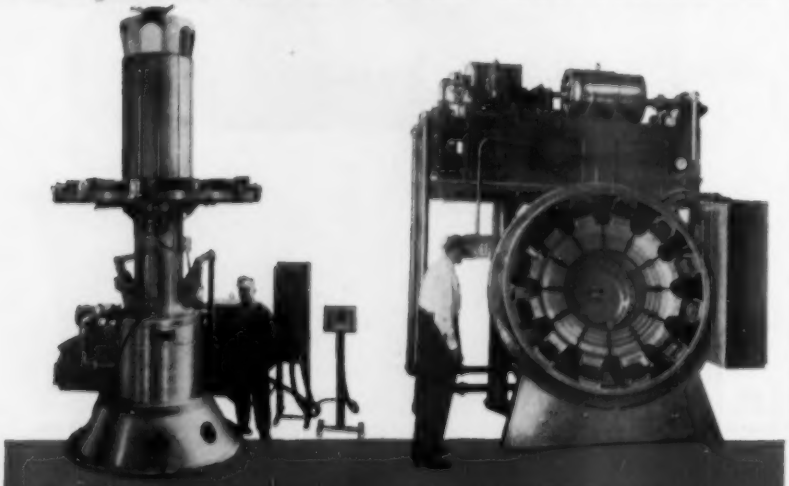

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sional and service personnel for basic research and development related to guided missiles. Annual payroll exceeds $9 million. Director of the laboratory is Dr. W. H. Pickering. Its principal contract, with Army Ordnance, is administered by Los Angeles Ordnance District.

In CalTech's Guggenheim Aeronautical Laboratory, special emphasis is being placed on studies of fluid and solid mechanics.

Fundamental theoretical studies are being conducted in the mathematical foundations underlying the flow of viscous compressible fluids and rarefied gases. Findings might apply to skin friction and aerodynamic heating of supersonic aircraft and missiles and, in the case of rarefied gas studies, the motion of missiles at altitudes of several hundred thousand feet.

One technique being used in connection with research with compressible viscous fluids is the shock tube. It affords moderate supersonic speeds but produces extremely high temperatures for a few thousandths of a second, corresponding to temperatures a missile encounters at hypersonic speeds. This permits study of heat transfer and dissociation and ionization of gases occurring with actual missiles at hypersonic speeds, where temperatures on the order of 10,000-30,000 degrees occur.

Another technique is the hypersonic wind tunnel, which reaches Mach numbers of about 10 at relatively low temperatures up to about 1,000F. This permits study of high-speed phenomena but not high temperatures.

Combined results of both techniques afford an insight into problems associated with missile flights through and above the atmosphere at hypersonic speeds.

Transonic Flight Emphasized

Considerable research is being conducted on air flow in the high transonic region, where most of the present military manned aircraft now operate, and where commercial jets will fly.

Interaction of shock waves and boundary layers, transition from laminar to turbulent flow, and aerodynamic noise—applicable to commercial jets as well as military aircraft—are being studied.

A special facility developed by the laboratory, essentially a wind tunnel, is used to study noise effects due to high-speed turbulent boundary layer.

Other fundamental scientific studies are related to propagation of very strong shock waves such as might be generated by explosions. Practical applications of this research have not yet been pinpointed.

In addition to fundamental low-speed research in the field of turbulence, wind tunnel studies—particularly in the 10-ft.,

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Dr. Ball is a leading scientist devoted to reliability efforts and programs, and is a prominent consultant to top management in aircraft and missile industries. His independent evaluation of the "HELPR" Program follows:

The State of the Art:

NEW TOOLS ARE HERE TO UPGRADE RELIABILITY *NOW!*

Dr. Leslie W. Ball

In 1940 Winston Churchill stirred the conscience of American industry by his confident plea . . . "Give us the tools and we will finish the job." Our industry did respond magnificently and gave the Allied Armed Forces the tools with which the immediate job of destroying the dictatorships was finished.

But we know only too well that neither in peaceful competition nor in military defence can industry rest upon past achievements. New tasks of staggering magnitude always will arise to challenge the imagination and guts of our industrial management and to challenge the thinking and action abilities of our design, production, test, and quality control engineers.

Today, a new challenge to managers and engineers is stark in its clarity, and voracious in its demand for action. Clearly, the marriage between the science of electronics and the science of systems engineering has been, and will continue to be prolific in the procreation of complex equipments that increase the productivity of peace-time industry and radically improve the potential effectiveness of our military defence. It is evident further that many top managements have seized upon these opportunities.

In those industries that are adopting automation, and throughout our defence program, decisions have been taken to entrust the future to the abilities of complex requirements. In the case of some equipments it is merely the financial future of a single company that has been committed. In the case of military equipment, our future in the world has been committed to the belief that complex weapon systems based on electronic equipment can be made to perform adequately in all respects.

DRAMATIC PERFORMANCE

In the first flush of excitement over the potentialities of radically new equipments, the abilities and energies of both managers and engineers usually have been concentrated on obtaining dramatic performance. In multitudes of offices and laboratories throughout the nation, equipment performance abilities worked out on the drawing board or predicted by electronic computers have been received with enthusiasm and adopted as target. As time has brought the conversion of calculations and predictions into actual hardware, it has become painfully evident that the ominous forebodings of a small band of pioneers, now known as "Reliability Engineers," were not without substance.

Much has been written about the fundamental relationships between unreliability and complexity in electronic equipments and about the incompatibility of extracting the last ounce of high performance out of equipments that must be reliable under conditions of high environmental stress and limited maintenance skill. So, today, the managers, upon whose shoulders rests the heavy responsibility for having taken decisions to commit their companies or their defence programs to complex high performance systems, must undertake an agonizing reappraisal of their electronic equipments within these systems.

BLUNT QUESTION

The blunt question that faces them is, "Must we retreat to simpler, lower performance devices, or is there an immediate line of reliability upgrading action whose cost is within reason and whose effectiveness is beyond question?"

The answer to this vital question is not to be found in academic discussions of the abstractions of reliability nor in the ivory towers of higher mathematics. It is to be found in the testing and analytical laboratories where countless analyses have been made of equipments that have failed in service or in which failure has been produced by simulation in the laboratory of service stresses.

The answer to the question "Must we retreat?" is a confident "No, we need not retreat. There is a path to electronic equipment reliability whose cost is within reason and whose effectiveness can be assured."

To define the path to reliability specifically and clearly, we must first express the underlying causes of equipment unreliability in engineering management terms.

Both technological advances and management action have provided the systems engineers with the tools that they need to work out complex system performance, and to generate sound preliminary designs. Unfortunately, in the electronic industry the detail designer, the production engineer, the test engineer, and the quality control engineer have not been provided with all the tools that they need to follow through from a preliminary system

State of the Art: NEW TOOLS ARE

design to delivery of a completely reliable finished product.

A FUNDAMENTAL CAUSE OF ELECTRONIC UNRELIABILITY IN TODAY'S ELECTRONIC EQUIPMENT IS THAT DESIGNERS ARE REQUIRED TO DESIGN CIRCUITS, QUALITY CONTROL ENGINEERS ARE REQUIRED TO CONTROL CONFORMANCE, AND TEST ENGINEERS ARE REQUIRED TO PLAN EVALUATION PROGRAMS WITHOUT MUCH OF THE BASIC HANDBOOK TYPE OF DATA ON WHICH THE RELIABILITY OF ALL OTHER TYPES OF ENGINEERING EQUIPMENT DEPENDS.

To illustrate this deficiency, suppose that the management of an aircraft company had made excellent provision to obtain systems engineering and a preliminary design for a new super performance complex rocket-powered plane and then assigned the task of detail design, quality control and test planning to their staff. But, with the provision that they would be denied anything approaching complete knowledge of the strength, endurance and failure characteristics of the materials and components of which the system was to be built.

The opinion of their customer and of other managers would be that this was a preposterous way to manage an engineering project, and unreliability in the product would be a foregone conclusion. *And yet, inadequacy in the organized knowledge of strength, endurance and failure of component parts is characteristic of almost all military and industrial electronic equipment projects.*

Management thinking about the provisions that they must make for providing their staffs with adequate knowledge of electronic component parts can be helped greatly by the following definition: "Any equipment component or part is inherently unreliable until every mode of failure is known, understood, measured and controlled."*

Throughout the mechanical engineering industries the truth and significance of this definition is accepted as self evident. Moreover, large quantities of organized knowledge on understanding, measurement and control of every mode of failure of mechanical parts are contained in engineering handbooks. For example, in the case of reciprocating machinery unreliability caused by the phenomena of fatigue is no longer tolerated because an understanding of the design and manufacturing factors that can permit fatigue to occur, together with tables and curves showing the relationship between stress level and number of cycles to failure and established quality control procedures, are all available in the form of handbook data.

URGENT NEED

The problem of the component part failures that cause unreliability in electronic equipment is analogous to fatigue failure in metal parts, but there are at least two important differences, each of which makes the need for handbook data more urgent.

First, the stresses imposed upon the part are more diverse. That is, the effects of placing an electronic component part in a complex circuit require rather more analysis and more types of data than required for the determination of the stresses on a part in a mechanical structure.

Second, the number of modes of failure resulting from variety in the materials and methods of construction of electronic parts are much greater than for purely structural parts that can fail only by such well known phenomena as tensile fracture.

Third, whereas mechanical parts are characterized by long service and laboratory testing histories that have resulted in well organized and widely published handbook data, electronic parts have either not existed long enough or have not been studied intensively enough for such handbook data to be available.

The contrast between disciplines in electronic and mechanical engineering is obvious. In the electronic industry, management and engineers must undertake immediate and imaginative action to generate and distribute handbook type data. This would embrace the understanding, measurement and control of all types of electronic component parts whose failure contributes to unreliability.

We may assume that this statement is beyond question, and the real issue for management and engineers to decide is "WHAT IS THE FASTEST, MOST ECONOMICAL AND MOST EFFECTIVE METHOD TO GENERATE HANDBOOK DATA?" The possibility of each company being dependent only on its own component part testing programs must be ruled out, because the cost is prohibitive and the time taken to get the job done on limited testing facilities would be hopelessly excessive.

IMPORTANT PECULIARITY

In this regard a very important peculiarity of electronic component parts must be recognized. This peculiarity may be called "the existence of minority groups in the manufactured population." For example, consider a population of one thousand capacitors produced by a particular manufacturer. From the point of view of performance, all these capacitors will belong to a single homogeneous population, but, from the point of view of reliability, the population is by no means homogeneous.

If the thousand capacitors were subjected to circuit stresses and to external environmental stresses, some of them would become "early failures" and others would become "random failures." Suppose that out of the thousand, ten are potentially early failures and another forty are potentially random failures. If a test sample of, say, six capacitors were chosen from among the nine hundred and fifty that will fail by wear out, the results of this test program would be completely useless and dangerously misleading because they would tell nothing of the unreliability that would be caused by the ten early and the forty random failures.

It follows that it is vitally important to subject the whole population of one thousand capacitors to an ambitious test program that includes statistical design of experiments, detailed analysis of failures, and statistical interpretation of results.

Even in equipments where a high failure rate of, say, one part in a thousand can be tolerated, the test sample size should consist of several hundred parts. In equipments where failure rates of only one in a hundred thousand can be tolerated, the sample size and consequently, the cost of the test program must be increased correspondingly.

IT IS THEREFORE APPARENT THAT EVEN LARGE ELECTRONIC EQUIPMENT COMPANIES CANNOT AFFORD TO UNDERTAKE TEST PROGRAMS TO GENERATE ALL THE KNOWLEDGE OF ELECTRONIC COMPONENT PARTS THAT THEY REQUIRE, AND THAT THEY MUST SUPPLEMENT THEIR OWN WORK BY PARTICIPATION IN A PROGRAM SUBSCRIBED TO BY A LARGE GROUP OF COMPANIES.

A second cost aspect is that the recording of test data by technicians reading indicating instruments is incompatible with the enormous number of readings that must be made to generate the amount and accuracy of data required for handbook purposes. Consequently, the principle of automation must be applied to the recording of data during component part testing programs.

Both the above cost considerations lead to the conclusion that electronic equipment manufacturers can reduce the cost of reliability programs radically by sub-

*"Management Use of Laboratory Testing to Achieve Reliability." A Paper presented to the University of California at Los Angeles Engineering Management Symposium in January 1955 by Leslie W. Ball.

HERE TO UPGRADE RELIABILITY *NOW!*

scription to testing programs performed in a competent laboratory, where sample sizes of thousands can be handled and where data can be recorded automatically.

STEADY FLOW

The general relationship between such a laboratory and the subscriber to such a program must go far beyond the mere provision of testing facilities and automation instrumentation. The laboratory must provide the subscriber with a *steady flow* of organized knowledge that makes it possible for the subscriber to diffuse throughout his whole organization "knowledge, understanding, measurement and control" of all the modes of failure of the electronic component parts used in the company's products.

While the above statement summarises the service that must be rendered and leaves no doubt that the benefits to be gained by subscription to this laboratory program will far exceed the cost to the subscriber, and while the brochure offered by the "HELPR" program provides detailed information to the individual engineer, it is to be expected that the subscriber's management will want a more specific summary of what will come out of the testing program, and of the identity of the departments within his organization that will use the output, and of the ways in which they will use it.

On the basis of work already done in similar, but much more restricted testing programs, the following five specific types of output and six specific types of application by subscriber's personnel may be identified.

FAILURE RATE CURVE— CIRCUIT STRESS

For each type of component part it is generally recognised that some particular circuit stress is of primary importance in regard to failure rate and reliability. For example, in the case of capacitors, the voltage across the capacitor is accepted as the primary circuit stress. Test programs for each type of part will result in a family of curves in which failure rate is the ordinate, time is the abscissa, and one curve is plotted for each value of the primary circuit stress.

In general, the curves will have a characteristic shape which in many cases will be the familiar three part curve showing early, random and wearout failures. The corresponding time intervals may be called the "infant mortality screening period," "service period" and "over-age period." Quite apart from numerical values of the failure rates, knowledge of the shape of these curves and of the duration of the infant mortality screening, service and over-age periods are vital to intelligent decisions on quality control and preventative maintenance requirements.

RELIABILITY INDICES

For those component parts that show a "random" failure rate in the service period, a single value for failure rate index may be established. In other cases an average value in the service range may be selected as characteristic of the part. All these values could be prepared in summary tabulated form suitable for use as reliability indices during the precalculation of the reliability to be expected from any new type of electronic equipment.

FAILURE RATE CURVES— ENVIRONMENTAL STRESS

It is well known that the failure rate produced by a primary circuit stress can be greatly modified by the environment in which the part operates. For example, in the case of capacitors the ambient temperature will have a major effect upon the failure rates produced at any given voltage.

It is recognized further that, when environmental stress becomes severe, entirely new modes of failure not directly related to the circuit stress are produced and that these new modes of failure will have their own characteristic failure rates. The test program should produce curves showing both the modification of circuit stress failure rates with environments, such as temperature of vibration intensity, and other curves showing failure rates produced by the environment in the absence of circuit stress.

MODE OF FAILURE ANALYSES

If the laboratory's service to the subscriber finished with the production and mathematical analysis of failures, the most constructive and universally applicable reliability upgrading information would be lost. The laboratory service should include detailed disassembly and analysis of the physical, chemical and mechanical modes of failure of each type of component part. The results and interpretation of these analyses will be available to the subscriber and to the manufacturer of the part.

CORRELATION OF FAILURE RATES WITH DESK ANALYSES

Obviously, test programs must be performed upon component parts bought from particular vendors, and, consequently, test results presented under the above four categories would be specific to each vendor. However, it would be chronically wasteful to limit the output of the test program simply to the products of the vendor supplying test items.

By careful analysis of the design characteristics of the parts, combined with knowledge of the manufacturing processes and quality controls used by the vendor, it is possible to establish extremely valuable correlations between failure rates and design and manufacturing factors. These correlations are universally applicable to the products of all vendors. The laboratory should seek to establish such correlations and will present the results in the form of technical reports to the subscribers.

USE OF TEST RESULTS

BY SUBSCRIBER'S PURCHASING DEPARTMENT

The results of the test programs will be of direct benefit to the purchasing departments in the selection of component part vendors. Even when a particular vendor's parts have not been included in the program, the subscriber's purchasing department would be able to make use of the test results in evaluating the materials and process controls used by the supplier.

BY SUBSCRIBER'S PRELIMINARY DESIGN DEPARTMENT

Whenever a new system or equipment is offered in a preliminary design proposal, it is a good management practice to require a precalculation of the expected reliability of the equipment if it is to be built from state of the art component parts. Although at this time the exact number of parts and the circuit stresses that will be imposed upon them are unknown, certain assumptions can be made based on similarities between previous equipment and proposed equipment. By combining these assumptions with reliability indices for the component parts, a precalculation can be made.

BY SUBSCRIBER'S DESIGNERS

During the design phase, decisions must be made on the general degree of part derating and on the amount of money, space and weight that will be allowed for reduction of environmental stresses. The test program would provide specific numerical values to guide both the amount of action needed and to indicate which changes will be most effective.

BY SUBSCRIBER'S PARTS APPLICATION ENGINEERS

It is well known that the failure rate for a given part depends greatly on the circuit stresses imposed upon it and that, in some cases, circuit stresses that are of little importance to the performance of the equipment are of major importance to its reliability. The test program should provide specific data for identifying the nature and magnitude of circuit stresses that must be considered by the part application engineer in determining the suitability of a particular part for a particular application.

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BY SUBSCRIBER'S TEST ENGINEERS

Each electronic equipment manufacturer must make use of a great deal of testing in his own plant for both design and quality control purposes. For example, in the case of custom parts, such as special potentiometers, the subscriber must write his own specification and specify his own test methods. The results of the "HELPR" laboratory program would be valuable in indicating which tests are likely to be most effective for a particular type of component, and to give some significance to them when the size of the test sample has to be very small.

BY SUBSCRIBER'S QUALITY CONTROL ENGINEERS

It is generally true that the reliability of electronic equipment can be greatly improved by much more widespread use of non-destructive testing methods on the manufacturer's receiving inspection line and by cautious use of what is now called production environmental testing. The "HELPR" laboratory program would provide clear indications of which types of non-destructive testing can be most effective and information that should be sought by non-destructive methods.

In the case of production environmental testing, if this is done without the guidance of comprehensive knowledge of the shape of the failure rate curves and the duration of the infant mortality period, there is a very real danger that the environments will increase rather than decrease the unreliability of the equipment. However, with the type of information that the central laboratory program would provide, major improvements in reliability from carefully selected and controlled production environmental tests can be confidently expected.

* * *

The net result of all the above outputs from a central laboratory program and the application of these results by the subscribers could be momentous. Whereas, without a major program for generating handbook data on component parts, the electronic industry may have to retreat from the degree of performance and sophistication in designs now going into production. *With the proposed program, the horizons for the electronic industry become unlimited.*

Certainly in the case of industrial automation, the difference between a record of unreliability and a record of reliability will not only be a major factor in the success or failure of individual companies, but it will be the difference between a vast new surge of growth for the electronic industry as a whole, and a rapid saturation and ensuing stagnation if the market is limited to only those applications that can tolerate unreliability.

In summary, the new branch of the engineering profession that we call reliability engineers have done an outstanding job in recognising the nature of the problem, in analyzing its causes, and in delineating the path that must be taken to overcome the problem.

It is now up to the managers and the responsible engineers throughout the electronic industry to decide whether the American Electronic Industry will advance rapidly and lead the world in producing successful complex equipment, or whether we will hesitate and fall upon the hurdle of unreliability.

The "HELPR" PROGRAM

WIRE OR WRITE TODAY for the 52-page book, "The Handbook of Electronic Parts Reliability Program"—A Detailed, Systematic Approach. There is no obligation, just ask for the "HELPR" Book. Address:

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200-mph. facility—are being made to generate information on stability and control, high lift, landing conditions, etc. This tunnel also is used extensively by industry for development testing of actual prototype models.

In the field of solid mechanics, work is being done on vibration and flutter, particularly panel flutter, which occurs at supersonic speeds. Vibration characteristics of thin-wall cylinders under pressure (related to pressurized cabins and missile fuel tanks) are being investigated.

Considerable work is being done in the field of fatigue. Research emphasis is being placed on effect of elevated temperatures on fatigue properties of aluminum alloys, and on growth of cracks in pressurized cylinders. This work is largely supported by NACA and Air Force.

In the Jet Propulsion Center, a special activity established under the auspices of the Daniel and Florence Guggenheim Foundation, instruction is given to graduate students and research is conducted in combustion phenomena and rocket motor design and operation.

Tied in with these studies are investigations on guidance and control of rocket-propelled missiles. Facilities for this work include the Aeronautical Laboratory's experimental installations, CalTech's engineering facilities and JPL facilities. Prof. Duncan Rannie directs the center.

Director of the Aeronautical Laboratory is Dr. Clark B. Millikan. Engaged in research are 12 professors, 7 research fellows and 1 instructor, assisted by approximately two-thirds of the 100 graduate students.

Co-op Wind Tunnel

Southern California Cooperative Wind Tunnel, operated by CalTech for Convair, Douglas, Lockheed, McDonnell and North American Aviation, primarily is devoted to aerodynamic testing of prototype models of designs under development by the owner companies. Designs evaluated in the CWT have included the B-58, DC-8, F-104, F-101 and F-107.

Missile configurations evaluated here have included Triton, Navaho, Honest John, Nike and Corporal.

CalTech supplies the technical staff (about 200 people) to man the tunnel. Tunnel speeds are up to Mach 1.75. There are three test sections, subsonic, transonic and supersonic, measuring about 8 by 11 ft. to accommodate models up to 5 to 6 ft. in span, and operating at .1 to 4 atmospheres pressure.

Test sections are interchangeable by use of a track arrangement so that tests can be set up in one section while another is in operation. Dr. Millikan also is director of CWT. ■

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Cornell Research Has Great Freedom

By Alpheus W. Jessup

Buffalo—Philosophically as well as geographically, Cornell Aeronautical Laboratory's place in research and development lies between the university and production industry.

Although there is some feedback from the Laboratory's research program to Cornell University classrooms at Ithaca 147 miles away, contribution to the educational process is neither demanded of CAL staff nor established as a criteria for judging research projects.

The laboratory is similarly free from commitments either to a production line or to prescribed military doctrines.

CAL thus is as nearly independent as it appears practical for an applied research institution in aviation. About the only compromising factor is survival. Like its past growth, the laboratory's future existence depends upon income-producing research contracts from defense agencies or from private industry. It must therefore continually make research proposals which will win financial support from these sources.

Curtiss-Wright Gift

Cornell Aeronautical Laboratory was established Jan. 1, 1946, with the accession by Cornell University of the original facilities and personnel of the Curtiss-Wright Airplane Division research laboratory. In addition to the laboratory, the Curtiss-Wright Corp. provided $377,000 for the completion of the large wind tunnel.

Initial working capital of $675,000 was donated by Avco Manufacturing Corp., Bell Aircraft Corp., Fairchild Engine and Airplane Corp., Grumman Aircraft Engineering Corp., Republic Aviation Corp. and United Aircraft Corp. Avco, Bell, Fairchild, Grumman and United also contributed to the wind tunnel construction and its early operation.

Applied research in military technology makes up over 90% of Cornell's contracts in keeping with its continuing dedication to "full performance on behalf of the Department of Defense."

Non-military research for industry has been increasing and for the first time exceeded $1 million out of last years $13,800,000 contract total. Most of the industrial work is an outgrowth of military research. Example: Studies for General Motors on improvement of automobile handling and stability are based on techniques originally used in research in aircraft stability and control.

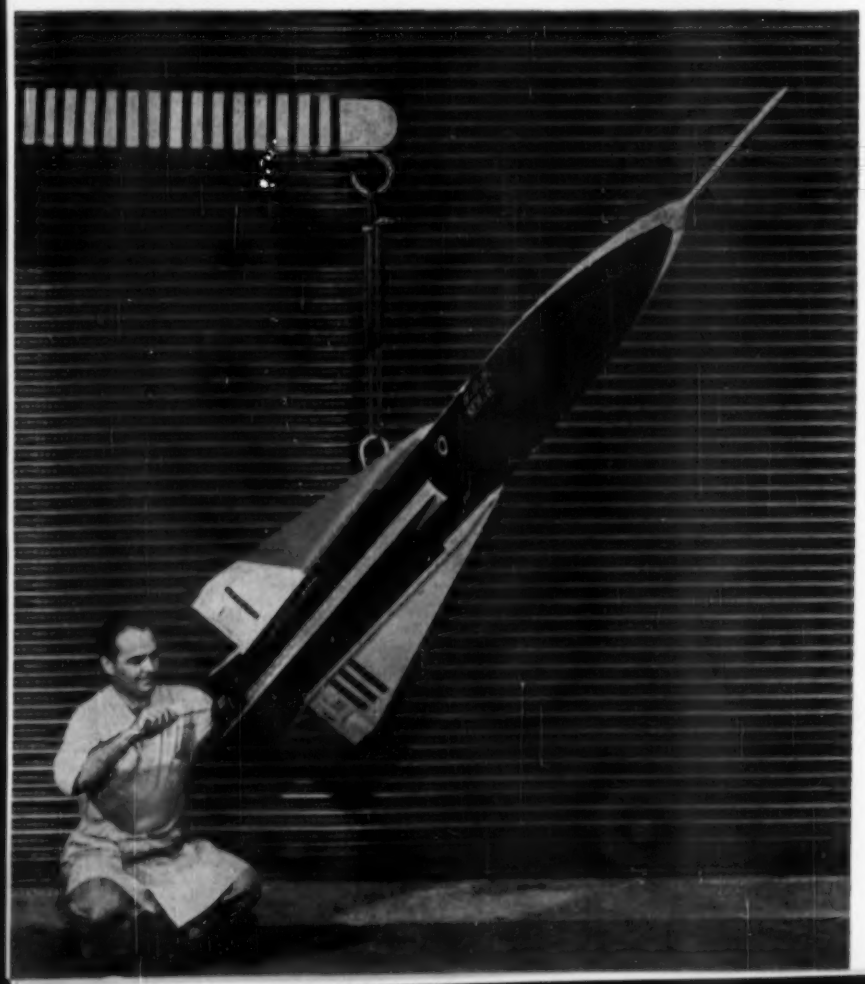
Academic Approach

Separation from the classroom and modern scientific management have not destroyed free academic approach to applied research. CAL has successfully restrained itself from getting involved in production and production problems. Management claims that the laboratory is not performing directed research.

Even the Lacrosse tactical missile meets the test of not being directed research. The project began as a Marine Corps requirement for a weapon to destroy hard top targets like bunkers and pillboxes. The Marines thought pretty strongly that the weapon should be built around the helicopter.

CAL's first step was to make a detailed analysis of the hard top target problem and of possible systems that might be used. It neither accepted nor rejected the helicopter as an essential part of the weapon system. As a result of its research and analysis, CAL concluded that a truck mounted missile system would be more economical, effective and reliable—a verdict accepted by the Marines and Army. The project was eventually transferred to the Army.

CAL's EXPERIMENTAL missile built to test bomber defense missile control system.



Production to Industry

CAL carried the Lacrosse missile system through the entire research phase into early development. It did build a number of test and prototype missiles and managed a test firing program. But production for Army and Marines has been turned over to The Martin Co. which will make the missile at Orlando, Fla.

Other hardware resulting from Cornell's research contracts also are turned over to private industry for production although the Laboratory has built prototype of test configurations.

Problems of directed research and of production continually concern the CAL management. They feel the CAL was in the Lacrosse project too long, that it should have been turned over to industry earlier. On the other hand they recognize the risk that if the re-

CAL-DEVELOPED Lacrosse surface-to-surface missile for Army is test fired at White Sands Proving Grounds, N. M.

search organization gets out of a weapon system or equipment program too early, the project might be dropped.

No decision has been made but consideration is being given to not undertaking similar weapon system contracts in the future.

This may not be so much a result of the Lacrosse project as from the experience in the Plato Project for an anti-missile missile. The preliminary weapon system analyses for such a project involve a fairly sizeable scientific staff and thousands of man hours. CAL believes that research institutions of its type are freer to make unbiased studies of such problems but have a limiting factor in being less able to readjust to contract cancellation or transfer.

Better than 50% of CAL's research projects are "sole" source, that is they are projects conceived by the laboratory staff and "sold" to a sponsor who contracts for the laboratory to carry out the project. The remainder are research projects on which the laboratory is requested to bid by a sponsor or defense agency.

CAL actually bids only on a small number of those proposed to it.

Whether the project is self-generated or proposed from the contracting agency, it must meet certain requirements of the laboratory:

• **Technical uncertainty.** There must be enough challenge, perhaps exploration of unknowns expresses it best, in the research proposal to make it interesting to the exploring minds and creative talents of the laboratory staff.

• **Promise of value.** Projects must hold out promise that the answers if and when found will contribute to essential scientific and technical knowledge. Negative answers may be as important as positive answers.

• **Within laboratory capabilities.** Projects are evaluated against the competence of the staff and the possible augmentation of the staff. CAL undertakes proposals for which it has the nucleus of competence.

• **Follow through.** Assurance that wide dissemination of the technical results and information accruing from the project is demanded. The laboratory staff wants to get information out early, hoping for feedback from the services, industry and other research groups which will help it go on to newer fields.

The laboratory has established some negative criteria as well:

• **No interest in consulting.** It won't take X-number of men and attach them to a company staff to help solve production line problems.

• **Limits on reduplication.** It avoids doing the same task over and over again. Avco, for example, wanted Cornell to build its hypersonic shock tunnel on a crash basis. The laboratory refused. Having built one similar to that Avco wanted, CAL said that wasn't its business. It did, however, cooperate with the designing of Avco's shock tube and made available its research reports.

Cornell Facilities

WIND TUNNELS:
Transonic/supersonic—to Mach 3; variable density; 1 x 1 ft.
Transonic—to Mach 1.3; 0.5 to 2.5 atmospheres; 8 x 8 ft.; 32,000 hp.

HYPERSONIC SHOCK TUNNELS:
One—Mach 15; 6,000K; test section 11 x 15 in.; duration 0.5 millisecond.
Two—Mach 15; 6,000K, test section 11 x 15 in.; duration 7 milliseconds.

WAVE SUPERHEATER:
Pilot Model operating, full scale device under design Mach 15 or greater; stagnation temp. 6,000K; duration 15 sec. or longer.

ALTITUDE CHAMBER:
Sea level to 60,000 ft.; temp. to —35F; 30 to 10 ft.

BALLISTIC RANGE:
1,000 in.; guns and small rockets.

PROPELLER SKIN PIT:
To 8,000 rpm; blade angle —20 to 60 deg.

RAIN EROSION PIT:
To 1 in. per hour at 500 mph.

CREEP LABORATORY:
Creep furnaces (37); to 1,800 F. intermittent (cyclic loading; bearing, sheer and compression creep; liquid environment). Stress relaxation units (8)—Load to 10,000 lb.; to 1,600F.

COMPUTERS:
Reeves, Boeing, Electronic Research analog; IBM 704, Datatron digital; IBM card programmed calculators.

Fundamental Philosophy

There is no clearer presentation of the fundamental philosophy of Cornell Aeronautical Laboratory than this. The use of the shock tube for testing aircraft and missile shapes was a Cornell-generated project. When it was completed, it was used as a laboratory tool, but also as the foundation for the de-

TEST specimens are cast by metallurgists in search for new high-temperature metals.

velopment of the hypersonic shock tunnel—a shock tube incorporating a wind tunnel nozzle. Improvement of shock tunnels and their use has continued; but CAL seeking another jump in testing equipment began developing a wave superheater which will test aircraft and missile configurations in continuous airflows of Mach 15 or greater at stagnation temperatures of 6,000K for 15 secs. or more. Flow Mach numbers can be varied and controlled.

CAL says it should use its talents to broaden the use of such research devices and to seek new research tools, it shouldn't stop to build hardware which other people could build using the results furnished by the laboratory.

Research projects at CAL are varied in scope and cost. Lacrosse was a complete missile system. The wave superheater is a $2,000,000 contract. Others range down to a few thousand dollars.

Research Diversity

Diversity of aeronautical research at CAL can best be understood by this survey of areas of interest with a sampling of types of projects:

• **Aerodynamics.** Development of transonic and hypersonic test facilities have been among the most widely known activities of CAL. Its perforated throat for transonic wind tunnels aids in generation of good flows, prevents choking of the test section and reduces strength of reflected shock waves. Besides installation in its own wind tunnel, CAL has assisted in the development of a perforated throat for the transonic tunnel located at Arnold Engineering Development Center, Tullahoma.

Hypersonic shock tunnel—a shock tube with a wind tunnel nozzle—produces airflows up to Mach 15 with simulation of the high stagnation temperatures for short durations of about one to seven milliseconds. Along with this came the development of instrumentation which would accurately measure force, pressure and heat transfer rates during the short test run.

Now, CAL is embarked on the $2 million project for the Air Force Office of Scientific Research to build the wave superheater to test aircraft and missile configurations. Pilot model of the wave superheater has been operated successfully. The new facility will simulate true free flight of aircraft and missiles for the study of materials, structures and aerodynamic problems at hypersonic speeds. It should be able to duplicate such flight profiles as the ballistic missile re-entry.

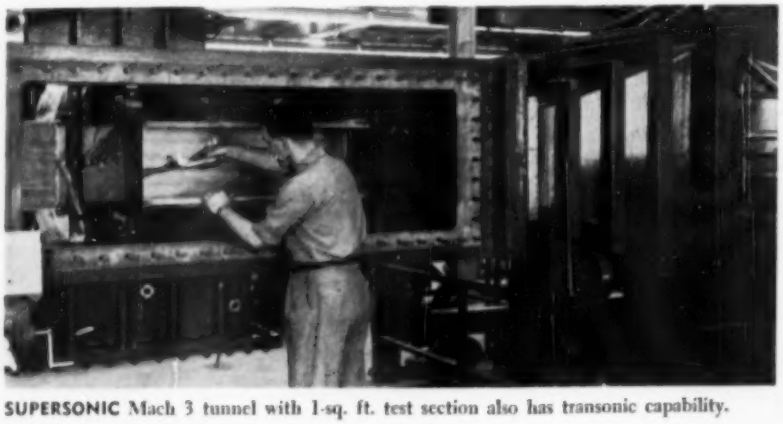
In addition to research in hypersonic flow, including heat transfer, CAL emphasizes study of low aspect ratio wings and wingbody interference. Franklin K. Moore, head of the Aerodynamic Research Department, points particularly to new programs in low speed flight. Missiles and aircraft that will fly at speeds of Mach 15 will still have to pass through flight from Mach 0 up. There are many gaps in our knowledge of what happens to low-aspect ratio wings at such speeds.

• **Aeroelasticity.** CAL has been involved in flutter research almost from the day the laboratory was established by Curtiss-Wright in 1943. Recently completed research project investigated the transonic flutter behavior of swept, straight and delta wings. Other interests are propeller stall flutter and helicopter rotor flutter. Next projects will be run in conjunction with the wave superheater on flutter phenomenon at hypersonic speeds and high temperatures where the stiffness of structures may vary.

• **Stability and Control.** Full scale research on dynamic stability and control of aircraft has been a continuing program for over 10 years. Current projects cover measurement of dynamic and control characteristics for high performance aircraft including those at transonic and supersonic speeds, study of flight characteristics using variable stability and control systems, measurement of atmospheric turbulence, and study of flight maneuvers involving strong inertial cross-coupling.

Design of future jet aircraft may be improved as a result of longitudinal and lateral stability and control data collected using a specially instrumented North American F-100. A comparable program involves an XH03S-2 helicopter, on which all the helicopter dynamic stability derivatives will be evaluated.

Handling qualities of the Convair B-58 Hustler supersonic bomber were simulated before the bomber was built



SUPERSONIC Mach 3 tunnel with 1-sq. ft. test section also has transonic capability.

Budget Not Sole Answer to Research

Better understanding of the research process and better management of the nation's research effort are now of greater importance than larger research budgets, according to Ira G. Ross, director of Cornell Aeronautical Laboratory.

"Research is not an industry. It cannot be measured by traditional standards of bigness," Ross says in warning against a "dangerous tendency for research to become a popular toy."

Trend for industrial companies to budget large sums for research and to build up large research staffs alarms Ross, who has been engaged in research and research management since 1928. Although the intentions to look ahead and come up with new things are good, Ross finds the record tends to be bad, with research personnel always being tied up in solving problems for the production departments.

Weapons research and early systems evaluation must be a continuing process of looking at everything. Today in Ross' opinion the subjects should be alternate systems and weapons for 1970 and beyond.

"Now, we can afford 30, 40, or 50 new weapon system research projects for the future," he claims. In fact he feels we can not afford less than the maximum number of scientifically justifiable projects which seek to find the answers to the next generation of military requirements.

Often this may seem like duplication, but only by thorough examination of all the permutations can we guarantee the best weapons for future defense, Ross says.

On the other hand, we should not be researching 15 different systems to do the same defense assignment in 1965. Gestation time for weapon systems runs about 10 years, with an overlap of about five years. Five years ago we would have been justified in having many approaches under research examination for the 1965 requirement, according to Ross, but not now.

Not only must industry recognize the proper role for research but so must Congress understand these fundamentals and be willing to support a multitude of early research and evaluation projects. Costs actually are small in the early stage, running from $100,000 to $2,000,000.

Ross, like many scientists, believes that the recent consolidation of research and engineering under one assistant secretary in the Department of Defense was right. He says research and development and engineering are inescapably linked because a weapon or a weapon system must be gotten to the prototype stage and into production.

Equally, he insists research, development and engineering are different. Here is the crux of the scientists' fight against the appointment of Frank D. Newbury as the Assistant Secretary for Research and Engineering. They had absolutely no confidence in Newbury's ability to manage and to listen without bias to the research experts as well as the production experts, then resolve whatever differences there might be.

Ross says top defense officials must depend on the staff work of experts on research and of experts on production. Industrial management, if it is to get maximum value from its investment in research, must do likewise.

Hampering the defense research effort today is the method of research procurement, says Ross. A major recommendation of the Ridenour Committee report which led to the creation of the Air Research and Development Command was a research procurement agency. ARDC has never had this group.

Result is that the quality numerator of performance is being judged by the technical agency sponsoring the research, while the business denominator is determined by procurement officers.

"When a research project is begun, who can say what you can deliver?" Ross asks.

Management of a research laboratory like CAL requires a fairly rugged mental constitution. Building up a backlog is pretty much out of the question.

"If you are contracting research two years ahead," Ross claims, "then you are not doing research." The exceptions to this are a few contracts where defense agencies contract just for what the laboratory can do, that is support research along very general lines with specific projects being decided from time to time.

Ross became director of the laboratory in 1954, succeeding Dr. C. C. Furnas, who became Chancellor of the University of Buffalo and later Assistant Secretary of Defense for Research and Development. Prior to this appointment, Ross had been head of the Wind Tunnel Department and of the Flight Research Department. He was manager of Flight Research for Curtiss-Wright when Cornell Aeronautical Laboratory was founded.

by CAL using an F-94 modified with a variable stability and control system. Improvement of handling characteristics for the Hustler were made while the first prototype was being built.

The F-94, like a B-26 used previously, was modified for variable longitudinal stability and control. First application of variable system was made on an F4U-5 for lateral control.

Now, a T-33 is being equipped with variable system for rudder, ailerons and elevator. With it, it is hoped to simulate the stability and control characteristics of aircraft yet to be designed.

Another new project will adapt the automatic control equipment for zero-G loading experiments. Previous studies of how man performs under zero G conditions have been accomplished with manual control of the flight trajectory and high probability that zero G conditions were not maintained closely enough.

• **Materials.** Search for lean alloys using inexpensive and non-strategic elements as substitutes for strategic materials, creep and rupture testing, fatigue studies, heat transfer investigation, improvement of structural plastics at temperatures up to 700 F., and studies of rain erosion figure prominently in the materials research program. With the move into hypersonics, no diminution of materials study is expected. Completion of the wave superheater will augment the materials department's tools, giving it the opportunity to investigate heat transfer and materials behavior under very high temperatures in close to free flight conditions for reasonable time durations.

Among the heat transfer problems under study are the new rapid fire guns. High temperature and high rates of conduction tend to "cook off" rounds of ammunition. Projects have measured the temperatures involved, developed modifications and recommended cooling systems to keep guns from getting so hot that heat rather than trigger fires the round.

• **Structures.** Current programs include investigation of structural and vibrational characteristics of supersonic propellers, loadings on missile components, air supported radomes and determination of effects of aerodynamic heating on aircraft structures.

Future programs will be run in asso-

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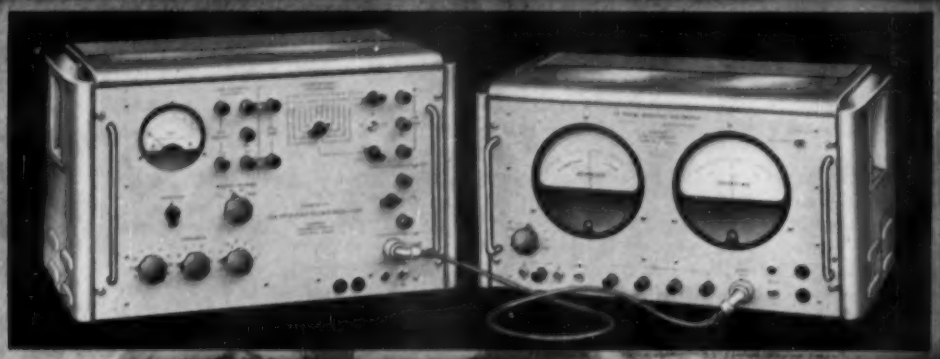

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ciation with the wave superheater facility, investigating structures of missile and aircraft configurations in sustained airflows above Mach 15 and in stagnation temperatures of 6,000 K.

Equipment for accurately measuring surface strains under very high temperature test conditions have also resulted from the structural program.

• **Aircraft design.** Projects have covered boundary layer control applications, supersonic cockpit requirements, designs for chemically-fueled engines, unconventional aircraft studies and evaluation of foreign aircraft. Unconventional aircraft studies were not aimed at production of hardware but at evaluation of the technical problems and feasibility for various short field and vertical takeoff conceptions, and powerplants including ducted fan engines.

• **Propulsion.** Flame propagation studies have been carried on continuously since 1946. Current research in flame propagation in high velocity gas streams has application to nonsteady flow operations of jet engines. Other interests have nonsteady flow in ducts, ramjets and valveless pulsejets.

• **Flight Instrumentation.** Immediate problem facing any scientist in advanced aeronautical research is adequate instrumentation. First he needs instrumentation which will quantitatively and qualitatively measure the data for evaluating the research results. Second, he must create instruments that enable the eventual hardware to fulfill its

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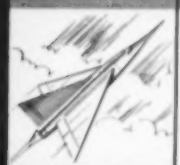

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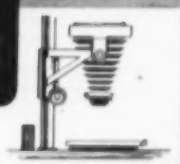

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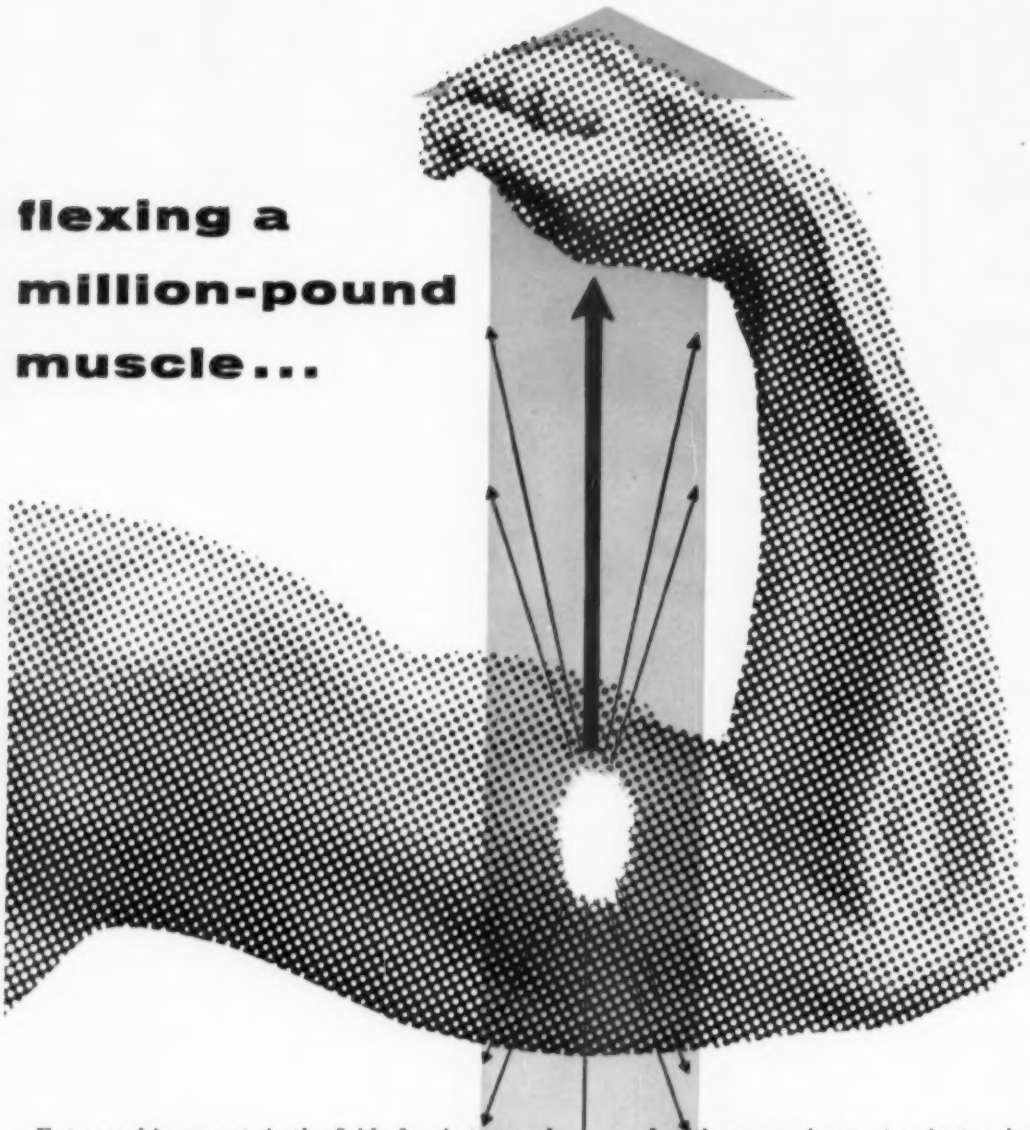

Future achievements in the field of rocket propulsion depend upon the ability to test prototype engines at rapidly increasing power levels. To keep pace with these higher power requirements, RMI is completing work on a giant rocket test stand.

The new RMI test structure is capable of testing rocket engines in the million-pound thrust class. Its massive rotating system provides firing attitudes from vertically downward to 45 degrees above horizontal. The control center contains a maze of instruments that continuously record separate events occurring, within the engine, at intervals ranging from one-tenth of a second to less than one millisecond . . . and with accuracies up to ninety-nine per cent.

This addition to RMI's already-extensive test facilities paves the way for tomorrow's more powerful and more efficient rocket powerplants. It's another example of how RMI — America's *first* rocket family—is continuing to pioneer in the development and production of new engines for supersonic manned aircraft . . . helicopters, catapults and test sleds . . . and missiles for defense and space exploration.

Engineers, Scientists — Perhaps there's a place for *your* talents in RMI's expanding organization. Our new projects present challenging problems and the chance for greater responsibility.

Power for Progress

4875

RMI

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NAVY is field testing CAL's experimental Intercept Tracking and Control equipment.

mission at new ranges of speed and temperature.

CAL developed computers late in World War II to provide data required for improving airborne fire control. Later this was extended to cover speeds of subsonic jet fighters. Now the program is directed toward use of these flight line computers in transonic and supersonic speed ranges. Using a special yaw-pitch pitot static tube and small temperature probe as the only external sensors, the airborne computers measure angle of attack, angle of sideslip, Mach number, relative air density and true speed to fine tolerances.

Vortex tube instruments for the measurement of free air temperature and true airspeed have been developed from the Ranque-Hilsch tube. The free air device is smaller than a pocket cigarette lighter.

Other instrument research includes low airspeed indicator for helicopters, a device to rapidly sample water droplet size and distribution in cloud formations, equipment for detecting and measuring gamma radiation, a gaseous flow meter based on transit time of ions, pressure and temperature recorders for atomic energy tests.

• **Electronics.** Research in electronics ranges from components to complete systems. In the latter category are: Intercept Tracking and Control Console for controlling Navy carrier fighters to bomber intercepts, bomber defense missile system controlling a missile fired from a fast moving bomber; also, major elements of systems, such as the deck motion probability computer for the automatic, all-weather carrier landing system.

In the component area, CAL has been studying the heat transfer problems in subminiaturization of components.

Radar research includes modification

ROCKET POWER PROGRESS REPORT

Servicing Rocket Engines

Part I: Know-How

by Fred Barker

Supervisor of the Product Service Department at Reaction Motors, Inc., Mr. Barker coordinates the activities which keep rocket engines on their good behavior. A graduate of New York University, with a B.S. in M.E., he has had diverse experience in engineering—including test, manufacturing liaison and customer service liaison. Mr. Barker joined RMI in 1949.

"Know-how" in any business is the result of thorough training and experience on specific products. RMI Product Service Department personnel get a complete grounding on their products right from the development stages through field installation and operation. The know-how thus attained is turned into a direct benefit for all RMI customers.

Key service engineers and service representatives join a project during early development, work actively with Engineering, Component Development, Assembly, Test and Inspection Departments. Mock-ups are reviewed from the standpoint of service—i.e., whether proper consideration has been given installation, accessibility and serviceability of components and the overall powerplants.

When a project is ready to move into the field, these same key men act as instructors, conducting training programs to impart their accumulated knowledge to customer personnel and other service representatives. With our ROR powerplant (rocket-on-rotor for helicopters), for instance, Sikorsky, Navy and Marine Corps personnel attended training programs at RMI and in the field. Scope of these programs covered the rocket powerplant, its installation and operation in the Sikorsky HRS helicopter, and the use, transfer and storage of the hydrogen peroxide propellant. Once ROR settled into operations at the Marine Corps Air Station, Quantico, Virginia, the service representative's know-how assumed a stand-by character. Training programs were repeated or amplified only as required by personnel changes or powerplant modifications.

Safety is a major item in each RMI representative's assignment, because safe use of the powerplant and safe handling of propellants are of paramount importance. Safety is improved by service representatives through on-the-spot lectures and training programs, whereby procedures and policies are outlined and integrated into the activities routine. Again, at Quantico, an admirable safety record has been achieved and maintained in just this fashion. There, over the past few years, our service representative has assisted the Marines in safely utilizing the ROR powerplant and the hydrogen peroxide fuel for their HRS helicopters. The result is found in the simplicity of powerplant operations, peroxide handling and storage area procedures, and in the attainment of a "no personnel injured" safety record.

Obviously, know-how is of importance in a clutch situation. Wisely applied, it leads to the right decision and the proper corrective action on the scene of a problem. The recently launched Glenn L. Martin No. 13 Viking missile provides a case in point. Pre-static firing inspection revealed discrepancies in some components of our 20,000-pound thrust rocket engine. Normal field maintenance sufficed for all but one difficulty: a valve seat and poppet, scored by foreign material, required lapping to meet leakage specifications—but no lapping compound was on hand. Our service representative used common household cleanser, lapped the poppet and seat to within leakage specifications, and the program moved on with only minor delay. This difficulty remained minor only because prompt and proper handling prevented development of a major program obstacle. Immediate action was required; immediate action was taken.

In Part II, we shall examine the function of the service engineer and service representative in various areas of Product Improvement.

5240

If you desire one or more reprints of Mr. Barker's article, or would like to receive further information about employment at RMI, write to our Information Services Coordinator, Reaction Motors, Inc., 14 Ford Road, Denville, N. J.

Power for Progress

RMI

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Inspecting T2J mockup: (in cockpit) Tom Clancy, Engineering Manager Trainer Projects, NAA Columbus; (left to right) executive secretary Lloyd A. Chacey, retiring president Alfred H. Sanborn, president Elmer S. Barrett, all of Ohio Society of Professional Engineers.

Invitation to the best engineers in Ohio (...or anywhere else!)

This is a mockup of the new T2J Navy jet trainer, designed and engineered by the Columbus Division of North American Aviation.

Displayed at the invitation of the Ohio Society of Professional Engineers at its 1957 annual meeting, the T2J is a graphic example of U. S. Naval aircraft engineering progress. It is the logical follow-on to the long line of distinguished standard trainers for which North American has been famous for over a quarter of a century. Designed as a basic trainer for jet pilots in all branches of the Armed Services, the T2J's performance is equal or superior to the nation's first jet fighters.

As an engineer, you can appreciate that many of our interesting projects cannot be exhibited in a public place. The performance and ability of these new aircraft startle the imagination of even the most advanced engineers. The requirements they impose offer challenges to every engineer currently working on them. They will do the same for you.

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Contact: Mr. J. H. Papin, Engineering Personnel Manager, Dept. 56 W-6, North American Aviation, Inc., Columbus 16, Ohio.

THE COLUMBUS DIVISION OF

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of a CW radar for the Weather Bureau for use in tornado warning and tracking.

Still another project is determination of radar cross-sections for bodies of rotation, obviously missiles.

• **Atmospheric Physics.** Thundercloud electrification, jet stream detection, icing problems, condensation trails, doppler signatures for various weather phenomena and electrostatic charging are among the atmospheric study areas.

A new theory which increases by ten times the corona discharge from thunderclouds was verified by corona discharge tests in the variable density transonic wind tunnel.

Equipment incorporating very sensitive electrostatic field meters for detecting jet stream remotely by electrical measurements has been installed in an airplane for a test program.

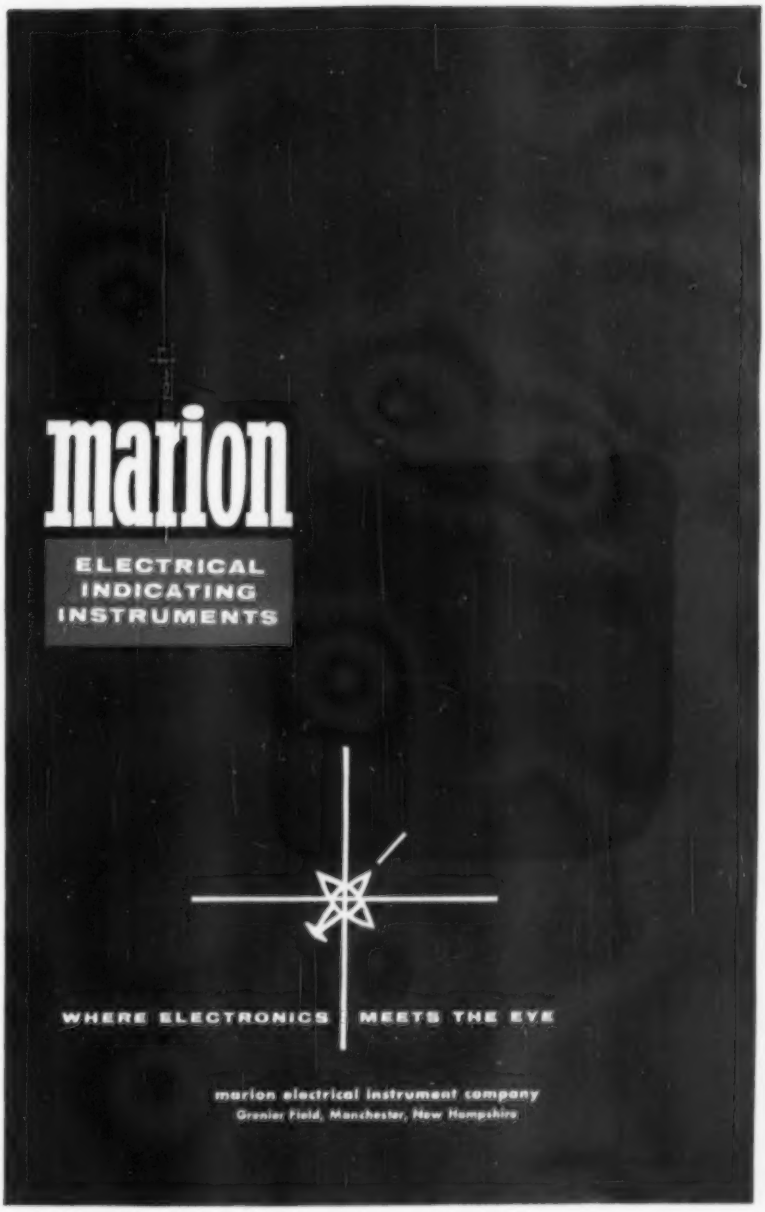
• **Weapons Engineering.** In addition to seeking solution to the cook off problems of aircraft guns, CAL has studied such problems as bomb separation from aircraft at subsonic, transonic and supersonic speeds. This may be applied to separation of rockets and guided missiles from high speed aircraft.

• **Weapon Systems.** CAL tackles weapon system work from two directions. One is the design of weapon systems, such as the Lacrosse tactical surface to surface missile. Other design studies are a bomber defense missile system with the aerodynamic problems of rearward launching, guidance and control, and the early research on an anti-missile system under Project Plato for the Army.

Systems Research

Second is systems research. This covers a panorama of research in weapon and weapon system evaluation, feasibility studies in the preliminary design stage of weapon systems and establishing new system requirements. Typical of these system research projects were a study of Navy task force composition which suggested new fleet operational plans and ship dispositions, a project on continental air defense to extend the area outside of the U. S. in which an air defense battle would be fought. This latter project apparently revived the requirements for a long range interceptor.

Included also in systems research has been a complex of studies on tactical air war designed to assist the Air Force in developing a more effective tactical air capability. Beginning with an evaluation of available tactical air equipment, the projects now are examining how best to give tactical air both an atomic and non-atomic delivery capability and how to enhance the effectiveness of the systems available. Not only are the results taking the form of recommendations concerning techniques and pro-



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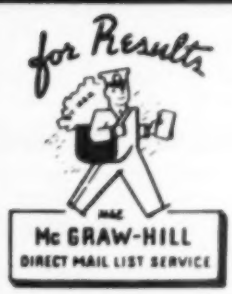

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cedures but also of new equipment specifications.

Organizationally, the laboratory is departmentalized under its managerial-executive group. Departments with their specialties are:

- **Aerodynamic research:** aerodynamics, heat transfer, aerodynamic test facilities and propulsion.
- **Aero-mechanics:** aeroelasticity, structures, helicopter research, electronic component evaluation and design.
- **Flight research:** stability and control coefficients, variable stability systems, flight test service for other departments, industrial research in automotive stability and control and tire dynamics.
- **Materials:** high temperature metallurgy, plastics, and heat transfer.
- **Physics:** electronics, aeronautical instrumentation and atmospheric physics.
- **Systems research:** systems evaluation and operations analysis, and weapons engineering.
- **Weapon systems design:** design and development of missile systems and analysis of new aircraft and missile system designs.
- **Engineering design and shops:** fabrication of devices and prototypes, and of test models of aircraft, missiles, flutter models and propellers for wind tunnels.
- **Wind tunnel:** operation of the 8-ft. transonic wind tunnel and development of techniques for wind tunnel testing.

Windtunnel Management

To some extent, outsiders' jokes about Cornell Aeronautical Laboratory being an adjunct to the large wind tunnel are true. But it has never been a joke to the CAL management. Failure to operate the tunnel efficiently could have put CAL in the red long ago; instead good management plus the nation's shortage of wind tunnel test time has made it the largest single source of income and a modest "profit" from the test fees has helped expand the other research facilities.

Originally a 12-ft., subsonic tunnel with a Mach .95 limit, the tunnel has been modernized with the CAL developed perforated throat into a transonic, variable density tunnel, operating from Mach 0 to Mach 1.3. Densities can be varied from ½ to 2½ atmospheres.

Scheduling, not sales is the prime task of the wind tunnel staff. The modernized tunnel went into operation in December. Occupancy averaged well over 400 hours per month during December and January and the February total was 500 hours.

Occupancy charges come to about $1,000 per hour. For this, the user can expect to get at least 500 data points per hour and the total may reach 1,000. In addition, data can be monitored during the test so that necessary varia-

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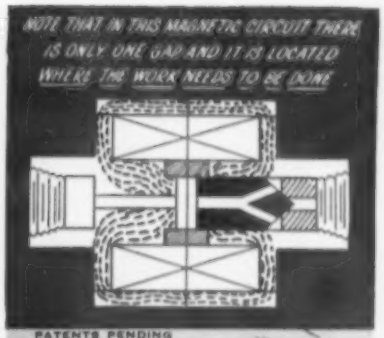

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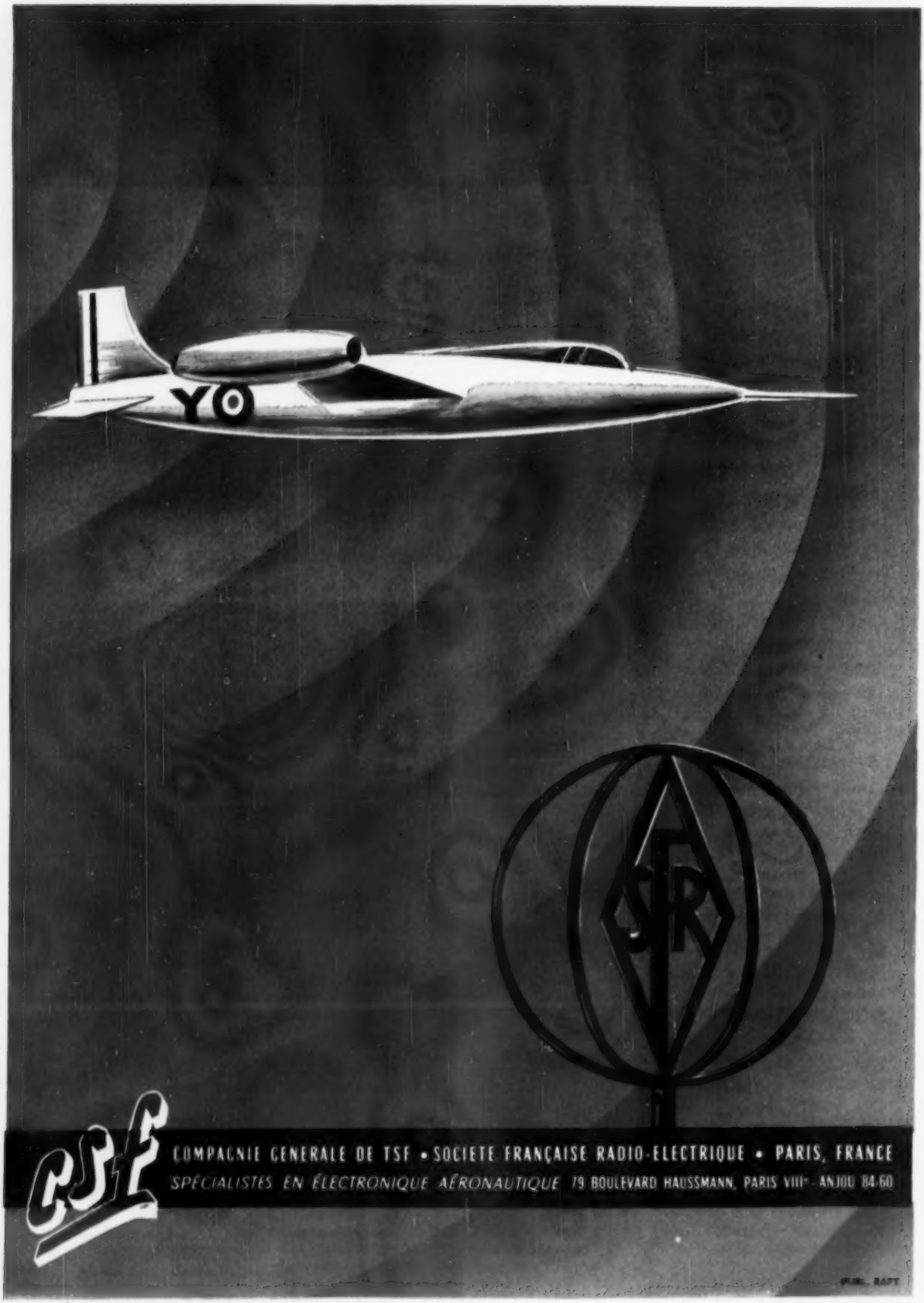
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tions in the test program can be incorporated at once. Typical six-component force data program with base pressure correction and two hinge moments requires 8 to 9 sec. for reading, computation and read out. Immediate analysis of results can thus be accomplished.

Among current operational aircraft that have been tested in the CAL tunnel are the F8U, F11F, F-100, F-101, F-102. A test program was run for the Caravelle French twin-jet airliner now on sales tour in the U.S. Also, the Saab Dragon, double delta supersonic Swedish fighter.

Departmental Autonomy

Each department is relatively autonomous. The department head is responsible that he has in hand enough work of sufficient scientific stature. Each department does its own "selling" for the laboratory has no sales department per se, only a contract department for administrative purposes.

A steering committee monitors the operations of each department. It reviews the proposals which the departments wish to "sell" to a sponsor. It also reviews proposals which the laboratory is asked to bid on. In both instances this is simply to check that the proposal meets the criteria earlier outlined. Occasionally it vetoes a department head's proposal. Usually, this takes place only when the department has been blinded by a low level of activity or in hanging on to a pet subject long after its value in research has been exhausted.

Naturally, many research proposals require the applied talents from many departments. However, the prospect is usually assigned to a project engineer who works under the general supervision of a department head, and he in effect subcontracts with other departments for the services he needs.

A significant phase of the CAL program is its internal research. Each department is allotted 100 hours of direct labor per month over which there is no audit. It uses this time to support fundamental research ideas of its staff. If the initial start looks promising the department may take it to the steering committee for review and for additional support; or it may be to carry it on its 100 hour program until it can be taken to an agency like the Air Force Office of Scientific Research as a firm research proposal.

Examples of internally supported ideas which have become advanced sponsored research projects are the perforated throat for transonic wind tunnels, transformation of the shock tube to shock tunnel, wave super heater for continuous flow hypersonic testing, and the investigation of low aspect ratio wings. ■

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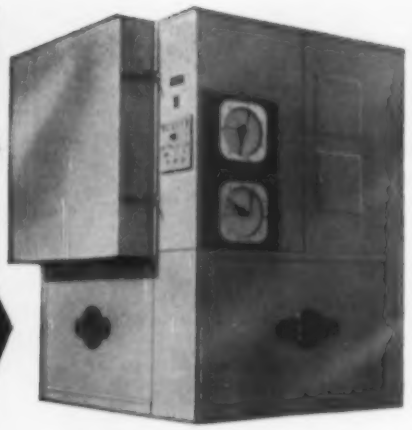

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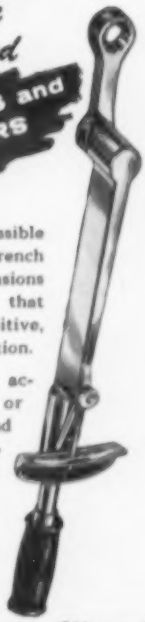

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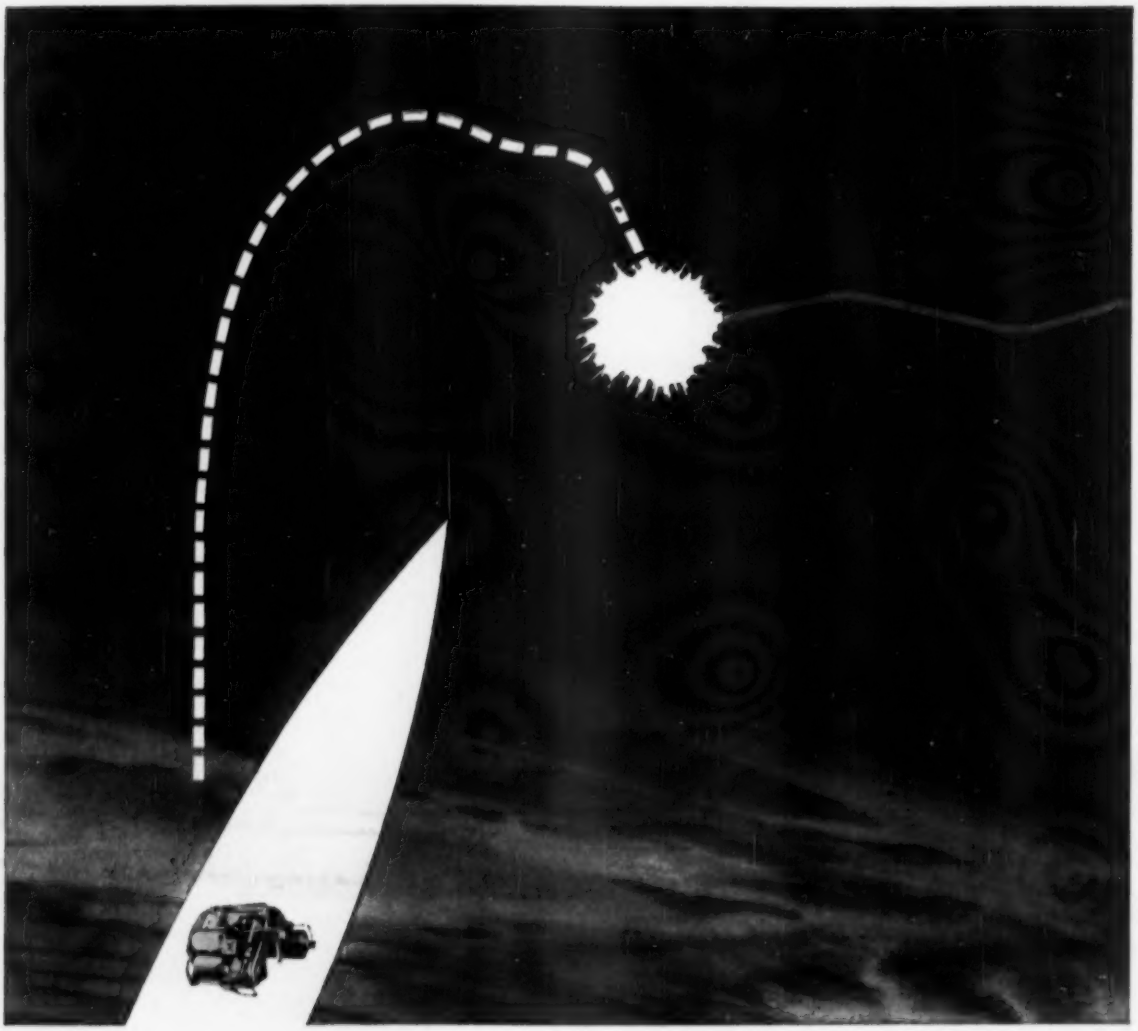

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Facilities Lag Hurts British Missiles

By William Coughlin

London—Britain's new shift in emphasis from manned aircraft to guided missiles may be endangered by the same thing that handicapped aircraft development here—lack of adequate research facilities.

Some of the nation's top scientists and technicians warn that it may once again be a case of "too little, too late."

It is now admitted, even by top officials in the Ministry of Supply, that Britain's decision not to build an X-series of high-speed research aircraft was a mistake which was in large part responsible for the failure of the fighter program.

Failure to initiate an adequate supersonic wind tunnel program early enough was another cause.

Five Years Behind U.S.

Whether a similar mistake now is being made in the missile program is a question being raised by some of the most experienced men in the field. Britain's guided missile development has fallen years behind due to a lack of proper effort and government support.

To catch up now—and to keep pace with the advanced weapons planned for the military's "new look"—will require a tremendous research and development effort.

The facilities situation is improving but many of those at work on missile projects say it is not improving fast enough, particularly in regard to ground test facilities.

When Prime Minister Harold MacMillan returned from his Bermuda talks with President Eisenhower, he said that guided missile development in the United Kingdom was five years behind that of the United States.

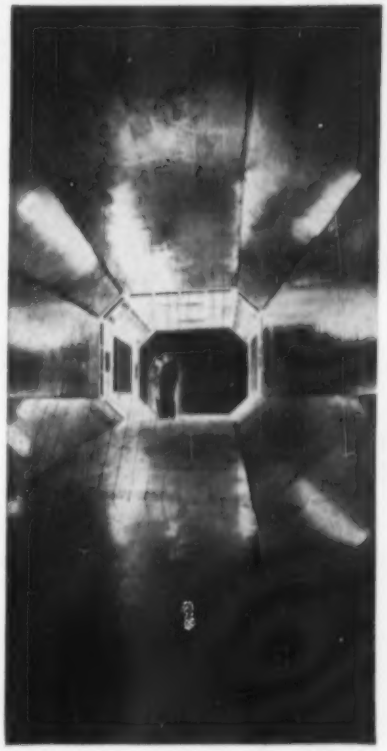
Commenting on that, the chief engineer of one of Britain's largest missile projects said wryly, "If you start five years late, it should not be surprising that at any given point you are five years behind."

To back up the bold conversion from manned aircraft to guided weapons outlined by Defense Minister Duncan Sandys, Britain not only must make up those five years but continue to move swiftly ahead in the field.

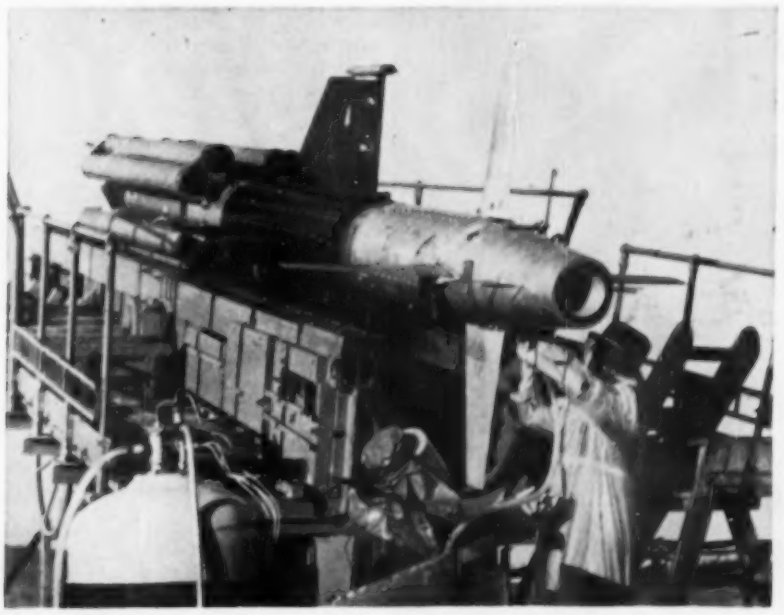
This is the situation at the moment:

• **Wind tunnels.** Greatly improved. But the late start in building enough supersonic tunnels still is slowing the program. Inability to get desired tunnel time has forced some firms into model flight testing as a less desirable alternative at a cost of many months of development time.

• **High temperature test facilities.** Poor. Existing facilities for test of small components are adequate but lack of large equipment to test thermodynamic effects on structures is one of the biggest problems handicapping the missile program. "If something is not done quickly, it could set back development of both missiles and high-speed aircraft," one engineer said.



BRISTOL Aircraft Ltd.'s new lowspeed tunnel is 10 by 12 ft., holds 9-ft. span model.



MISSILE is fueled with high test peroxide at Ministry of Supply's Aberporth range.

The question of whether expensive thermodynamic research facilities will be built by the government, by individual firms, or by a joint industry effort still is being argued.

• **Altitude chambers.** Good. Industry is well equipped in this field, particularly from viewpoint of the aerodynamicist.

• **Vibration equipment.** Very poor.

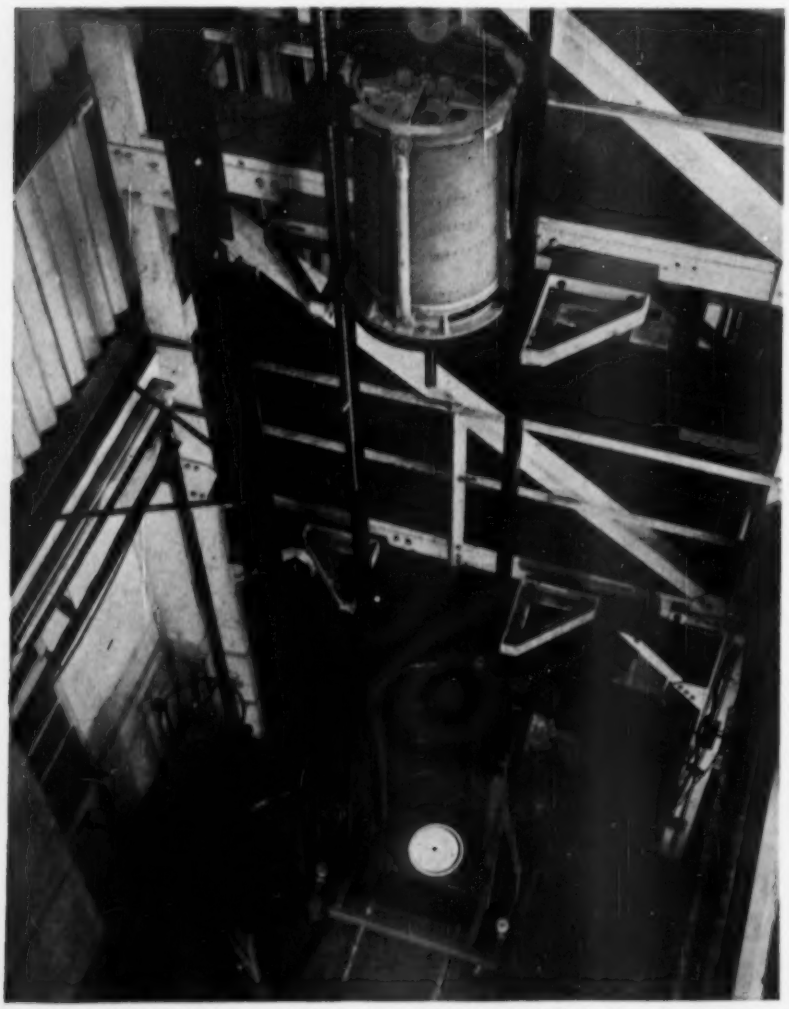
• **Centrifuges.** Adequate. Situation varies from company to company but there is considerable sharing of available equipment.

• **Ground climatic test equipment.** Adequate. Again, a question of sharing what is available throughout the industry. One of the largest missile firms has none whatever.

• **Engine test facilities.** Excellent. Britain's success in the engine field has laid the basis for investment by the industry in good facilities for both air-breathing and rocket engines.

• **Electronics.** Fair. With a few notable exceptions, the British aircraft industry

ENGLISH ELECTRIC vibration table tests component. Pen recordings are made of accelerometer readings while stroboscopic lighting system makes visual assessment possible.



MISSILE SECTION'S fall, arrested by spike penetrating lead block, reproduces boosted flight accelerations. This drop test tower is another English Electric facility.

has lagged behind the U. S. in application of computers and other electronic aids to research and development. Government facilities are better equipped. Use of simulators is increasing in missile development. Instrumentation often is not advanced enough for research projects, particularly in regard to altitude sensitivity.

• **Flight test facilities.** Good. Range at Aberporth on the Welsh coast is well-equipped for short-range testing and Woomera in Australia is an excellent long-range facility. The distance to Woomera results in irksome but not insurmountable difficulties. The recently-announced range in the New Hebrides is not planned for research and development testing, but will be used by the three military branches for service testing and practice firing of operational weapons.

Economy Called Threat

Industry spokesmen fear current government economy measures may hit research and development severely, putting Britain even farther behind. They say that while it has been too soon for cuts to show up in the estimates just submitted to Parliament, a definite threat exists.

Commenting on savings achieved in his new program, Defense Minister Sandys said they came in part from "curtailment of the research and development program." Edward Boyer, director of the Society of British Aircraft Constructors, followed this with a statement expressing grave industry concern. He warned of "disastrous" effects on the industry and "peril" to the national security.

Despite individual cutbacks, research and development funding has not yet suffered on an overall basis. Government estimates show that the Ministry of Supply plans to spend $43 million more on research and development in the 1957-58 fiscal year than it did last year.

Not all of this is in the aircraft and guided weapons field but it may be assumed that these, together with associated nuclear weapons development, make up most of it. Total to be spent on research and development of all types during the coming year is $576 million. The figures show that most of the increase in spending comes from financing of expanding research and development work by industry, rather than by government.

Spurred by economy measures, industry also is putting more of its own money into research and development facilities.

Center of the government's aeronautical research effort for all three military services is the Royal Aircraft Establishment at Farnborough. Its satellite stations include the missile range

at Aberporth, the wind tunnels at Bedford, rocket propulsion station at Westcott, blind landing and armament units at Martlesham, and the Larkhill range for testing rocket-powered free flight models.

At Spaedam, in the north of England, a sprawling RAE test facility is under construction for ground testing of large rocket engines, presumably to back up the development program for ballistic missiles.

RAE is charged with "fostering scientific investigation likely to lead to advance in all aspects of aeronautics other than those connected with turbine engines and radar." It also is responsible for evaluating new designs in aircraft, guided weapons and their equipment. The guided weapons department at Farnborough, using the large $2.8 million analog computer, TRIDAC, is carrying out much of the advanced research in the missile field, while the establishment's full-scale equipment for structural research and fatigue testing was highlighted by the Comet investigations.

Wind Tunnel Complex

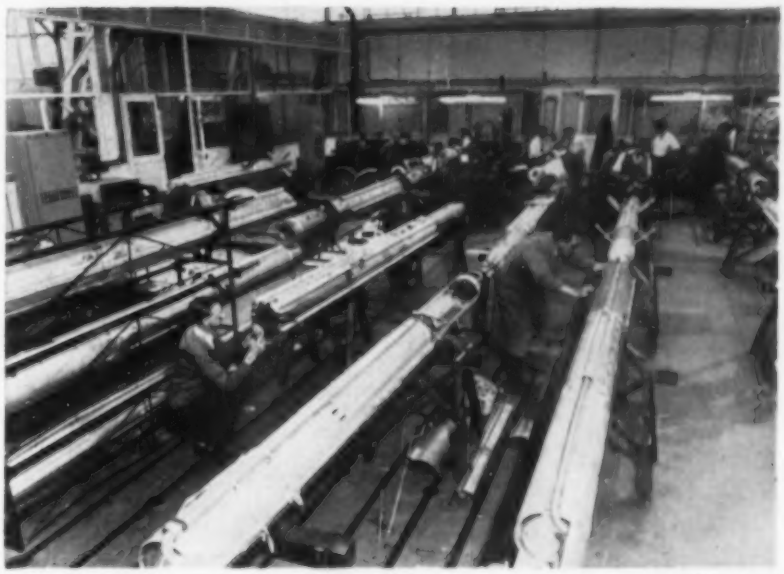
Much of the most important RAE work is done in the wind tunnels at Bedford and Farnborough. These include more than 20 tunnels ranging from low-speed through high subsonic and transonic to small, medium and large supersonic tunnels. There also is an advanced vertical spinning tunnel.

The large 8 by 8 ft. supersonic tunnel at Bedford, designed for a speed range from zero to Mach 2.7, is one of the newest tunnels in Britain. Air is circulated by a 10-stage axial flow compressor which absorbs 80,000 hp. To achieve the wall changes necessary for a range of air speeds, two of the tunnel walls are flexible steel plates, each 62 ft. long, 8 ft. wide and 1 in. thick. These can be bent to the required shape for any given Mach number by a number of hydraulically-operated jacks.

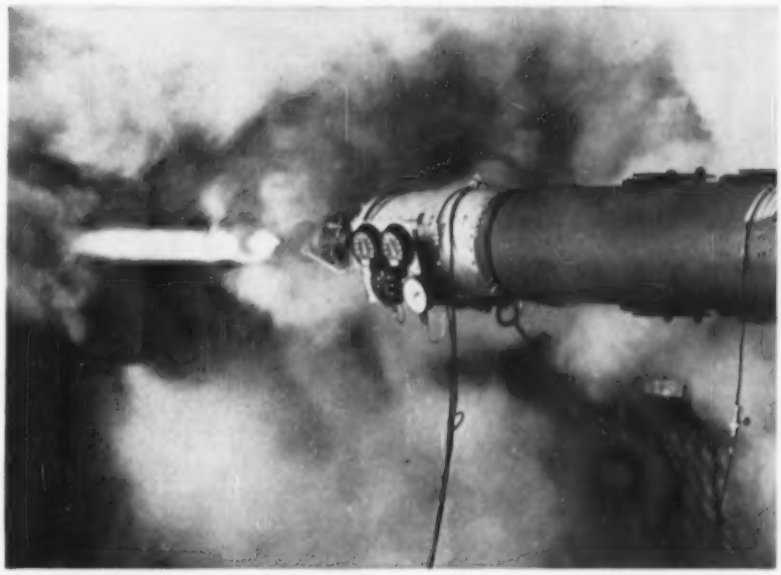
This tunnel is supplemented in the supersonic speed range by medium-sized tunnels ranging up to Mach 2. These include a 12,000 hp., 3 by 3 ft. tunnel at Bedford and a 7,000 hp., 1½ by 1½ ft. tunnel at Farnborough. The 3 ft. tunnel is designed for working pressures from vacuum up to 15 lb. psi. Changes of wall shape to vary the air speed are made by changing the top cover of the working section. Each of nine covers is provided with a teak liner shaped to give a different Mach number. Changes can be made in 15 minutes.

A number of small research tunnels covering speed ranges up to Mach 5 have been in use for some years.

One of the "newer" tunnels at Bedford is the 8 by 6 ft. transonic tunnel operating up to Mach 1.2. It is not



GUIDED ROCKETS are assembled in British Ministry of Supply rocket assembly shop. Ministry operates turbine, radar and aircraft and armament establishments.



LIQUID FUEL rocket produces shock cones in Britain's most advanced large rocket test facility at Westcott in Buckinghamshire. This is a Ministry of Supply establishment.

WIND TUNNEL building at Aircraft Research Association establishment in Bedford. ARA is a cooperative formed in 1949 by more than a dozen aircraft firms.

Sky Steel for Planes and Missiles

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Aircraft and missile design today is a challenge unequalled in any period of the past. Today's designers are proposing new shapes from new materials. Cameron's contribution to this era has been the development of an unusual forging process for large intricate ferrous components.

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British Wind Tunnels

Location	Working section	Speed range
RAE, Farnborough	11-1/2 x 8-1/2 ft.	400 ft./sec.
RAE, Farnborough	8 x 6 ft.	Mach 0.15-1.2
RAE, Farnborough	2 x 1-1/2 ft.	Mach 1.0-1.4
RAE, Farnborough	18 x 18 in.	Mach 1.3-2.2
RAE, Farnborough	9 x 9 in.	Mach 1.3-1.9
RAE, Farnborough	4-1/2 x 4-1/2 in.	Mach 1.9-2.5
RAE, Farnborough	5-1/2 x 5-1/2 in.	Mach 1.5-3.2
RAE, Farnborough	10 x 9 in.	Mach 1.3-2.6
RAE, Farnborough	10-4/7 x 5-9/16 in.	Mach 1.3-4.4
RAE, Farnborough	10 x 10 in.	Mach 4.8
RAE, Farnborough (four tunnels)	16 x 15 in. max.	Mach 1.4-5.0
RAE, Bedford (spin tunnel)	15 ft.	92-141 ft./sec.
RAE, Bedford	13 x 9 ft.	305 ft./sec.
RAE, Bedford	3 x 3 ft.	Mach 0.9-2.0
RAE, Bedford	8 x 8 ft.	Mach 0.0-2.7
RAE, Bedford (four tunnels)	9-1/2 x 10-1/2 in. max.	Mach 1.3-3.0
ARA, Bedford (cooperative)	8 x 9 ft.	Mach 0.6-1.3
NPL, Teddington	14 x 7 ft.	70 ft./sec.
NPL, Teddington	9 x 7 ft.	180 ft./sec.
NPL, Teddington	9 x 7 ft.	220 ft./sec.
NPL, Teddington	13 x 9 ft.	220 ft./sec.
NPL, Teddington (16-sided)	7 ft.	150 ft./sec.
NPL, Teddington (circular)	6 ft.	90 ft./sec.
NPL, Teddington	9.5 x 9.5 in.	Mach 0.0-1.8
NPL, Teddington	20 x 8 in.	Mach 0.0-1.6
NPL, Teddington	13 x 11 in.	Mach 1.2-2.8
NPL, Teddington	9 x 3 in.	Mach 0.0-1.8
NPL, Teddington	18 x 14 in.	Mach 0.0-1.8
NPL, Teddington	2.6 x 1.5 in.	Mach 0.0-4.0
NPL, Teddington	36 x 14 in.	Mach 0.0-1.8
NPL, Teddington	25 x 20 in.	Mach 0.0-1.8
Armstrong-Whitworth, Coventry	24 x 20 in.	Mach 0.3-3.0
Armstrong-Whitworth, Coventry	10 x 8 in.	Mach 0.3-1.5
Blackburn, Brough	7 x 5 ft.	300 ft./sec.
Bristol Aircraft, Bristol	8 x 6 ft.	120 ft./sec.
Bristol Aircraft, Bristol	20 x 15 in.	Mach 1.5-3.5
Bristol Aircraft, Bristol	12 x 10 ft.	300 ft./sec.
De Havilland, Hatfield	9 x 7 ft.	200 ft./sec.
De Havilland, Hatfield	2 x 2 ft.	Mach 1.0-1.6
English Electric, Warton	9 x 7 ft.	160 ft./sec.
English Electric, Warton	1 x 1 ft.	Mach 0.0-1.1
English Electric, Warton	18 x 18 in.	Mach 0.0-1.6
Fairey, Hayes	12 x 10 ft.	212 ft./sec.
Handley-Page, Radlett	7 x 5-1/4 ft.	220 ft./sec.
Handley-Page, Radlett	4 x 3 ft.	Mach 0.0-1.0
Handley-Page, Radlett	5-3/4 x 4-1/4 ft.	200 ft/sec.
A. V. Roe, Manchester	9 x 7 ft.	240 ft./sec.
A. V. Roe, Manchester	20 x 20 in.	Mach 0.4-1.6
A. V. Roe, Manchester	27 x 30 in.	Mach 1.6-3.5
Short Bros. & Harland, Belfast	6 x 4 ft.	250 ft./sec.
Short Bros. & Harland, Belfast	2-1/2 x 2-1/2 ft.	Mach 0.0-1.2
Vickers-Armstrongs, Weybridge	3 x 2 ft.	Mach 0.0-0.9
Vickers-Armstrongs, Weybridge	8 x 8 ft.	180 ft./sec.
Vickers-Armstrongs, Weybridge	13 x 9 ft.	340 ft./sec.
Westland, Yeovil	7 x 5 ft.	250 ft./sec.

really new, but was modified from a wartime tunnel at a cost of some $1.7 million. A transonic working section also is available for the 3 ft. supersonic tunnel.

Another RAE tunnel of interest is a 2 by 1½ ft. transonic tunnel, built into a bypass connecting the 8 by 6 ft. transonic tunnel with its compressor. A valve arrangement enables the compressor to be used as the main drive for the bypass tunnel when the main tunnel is not in use. This bypass tunnel will operate up to Mach. 1.4.

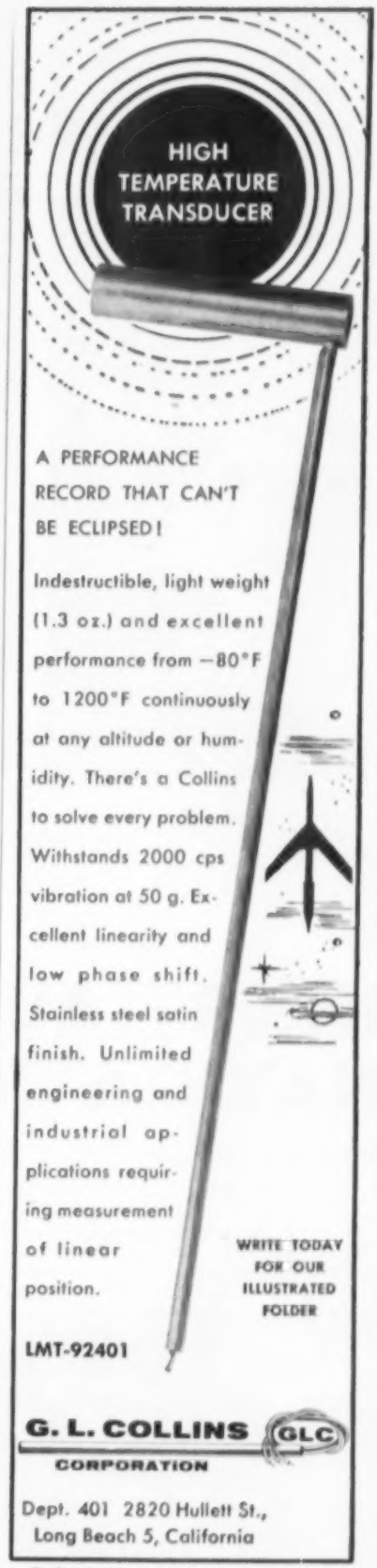
An intermittent tunnel plant at Farnborough provides four small tunnels. The largest, 15 by 16 in., is capable of short runs up to 20 sec. and Mach 4.5.

The vertical spinning tunnel consists of a steel shell 80 ft. high and 45 ft. in diameter with a fan and internal ducting to provide an air flow up the working section and down a return circuit around the edge. Working section is 15 ft. in diameter and can test models up to 3 ft. wingspan. Tunnel can be pressurized to 45 lbs. psi. Maximum airspeed at full pressure is 60 mph. and at atmospheric pressure, 95 mph.

RAE's missile test range at Aberporth is used for both ground and air launchings. Industry users describe it as an excellent facility.

Electronic apparatus includes a multistation Doppler system for measuring velocity and the usual array of radar tracking gear. A large section is devoted to recording of telemeter data.

All firing is controlled from a main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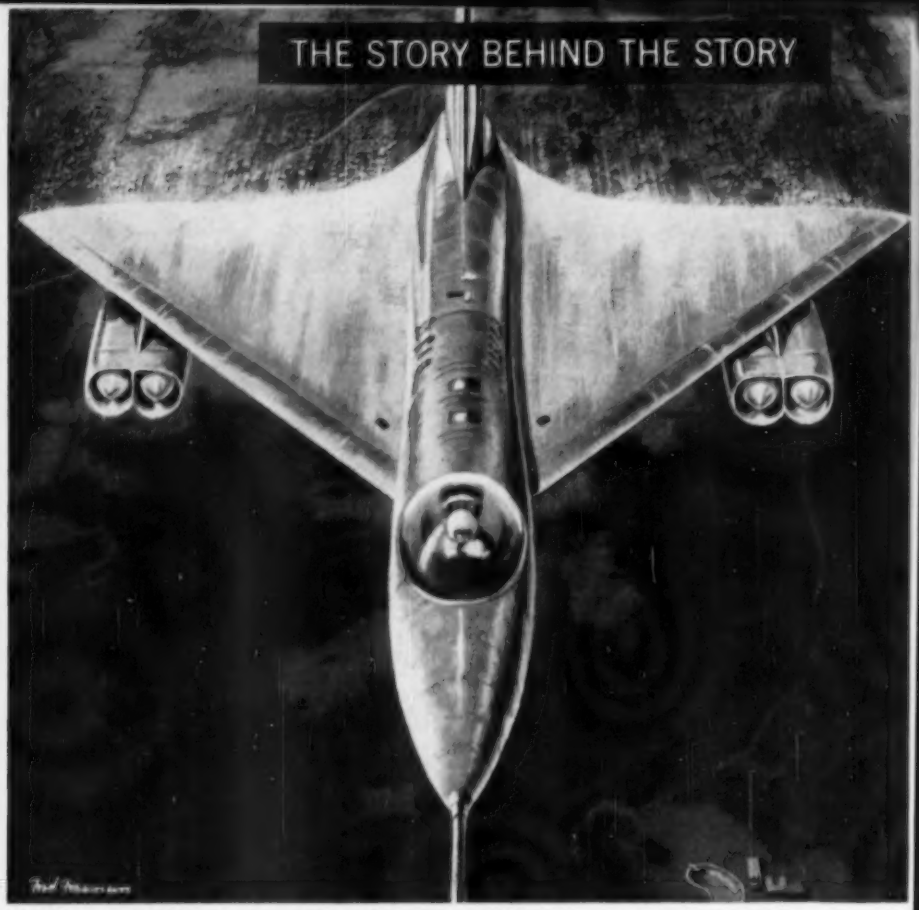
MISSILE CRUISER—Problem: To launch a missile 1500 miles from target. An error of only 1 degree in launching information would cause a 25-mile target miss.



SUPERSONIC BOMBER—Problem: To navigate undetected for thousands of miles to exact position in space for release of bombs or missiles.

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U. S. strategy for maintaining peace by making aggression unprofitable is based on our ability to deliver a crushing retaliatory blow anywhere in the world. Accurate means of directing such blows at long range, high speeds and extreme altitudes make would-be aggressors wary of breaking the peace.

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Solving such problems is the task of Inertial Navigation systems which furnish all data required *automatically*. Completely self-contained within the bomber, ship, submarine or missile, these Inertial Navigation systems require no contact with ground stations. This is extremely important when military missions must be carried on without chance of detection.

To design and engineer Inertial Navigation systems involves a complex combination of engineering skills—gyroscopics, computation, electronics, servomechanics and more. Their production calls for laboratory precision at every stage. For example, the gyroscopes which form the heart of Inertial Navigation systems must be many times more accurate than those used in commercial navigation.

At Sperry, Inertial Navigation systems are being produced for a wide variety of military applications.

ATOMIC SUBMARINE—Problem: To travel submerged for days and know exact spot to surface for missile firing.

SPERRY GYROSCOPE COMPANY
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DIVISION OF SPERRY RAND CORPORATION

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SCHLIEREN photo of missile model in Armstrong Whitworth supersonic tunnel.

operations room. Pilotless drones used in the tests are flown from Llanbedr airfield, about 50 mi. north of Aberporth. They are passed to the range controller after a controlled takeoff.

There are some 14 launching ramps, three of them zero-length launchers. Five more launching pads are under construction. Approximate number of firings per year at Aberporth is 1,000. Personnel strength at the station, which covers close to 300 acres on the coast five miles northeast of Cardigan, is about 500.

(For a complete report on the facility at Woomera, Australia, used by the British for long-range testing, see the April 22 issue AVIATION WEEK.)

Sister establishments to RAE in the Ministry of Supply include the Aeroplane and Armament Experimental Establishment at Boscombe Downs, the National Gas Turbine Establishment at Pyestock and the Royal Radar Establishment at Malvern.

Boscombe Downs corresponds to the U. S. Air Force Flight Test Center at Edwards AFB, Calif. It is responsible for experimental and development flight testing. Its armament responsibilities are more similar to the Air Proving Ground Command at Eglin AFB, Fla., being designed to prove out entire weapon systems.

Gas Turbine Establishment

The National Gas Turbine Establishment at Pyestock was set up in 1946. It has facilities for research work and component testing as well as a number of conventional test beds on which complete engines can be tested under sea level conditions. There also is a facility for altitude testing of ramjets and aircraft engines at supersonic speeds. Presumably, this can handle Mach 3 ramjets to altitudes in the neighborhood of 15 miles.

One of the larger test houses at Pyestock incorporates a 15,000 hp. steam turbine of the axial type, arranged to drive at either end so that compressors of either rotation may be tested. A 25,000 bhp. dynamometer is installed for use in braking gas turbines.

Another building contains a number of centrally located compressors that discharge into 24 in. diameter mains feeding compressed air to test cubicles along two sides of the building.

Two motor-driven compressors are capable of delivering 60 lb./sec. of air at a maximum delivery pressure of 74.8 lb. psi. An aftercooler reduces air temperature from 250C to 50C. It may be bypassed, however, with the air being further heated by a 1500-kw. electric heater for delivery to test cubicles at 400C.

An air-bleed gas turbine supplies smaller quantities of compressed air for special use.

Radar Establishment

The Royal Radar Establishment at Malvern is responsible for the development of electronic equipment for the three services as well as basic research in physics and electronics. It was formed in 1953 from organizations which helped develop Britain's wartime radar.

Computers, simulators and experimental test vehicles are used for study of missile guidance problems. Research also is being carried out on electronic techniques of data storage and high-speed computation. One of the first and fastest digital computers in Britain, TREAC, was designed at RRE.

The establishment is equipped for temperature, pressure, humidity, vibration and shock testing. Now under construction is a large new laboratory for research in solid state physics.

A large part of RRE's postwar research work in physics has been devoted to semiconductors. It is equipped with facilities for low temperature research for this purpose and also is well equipped for infrared studies.

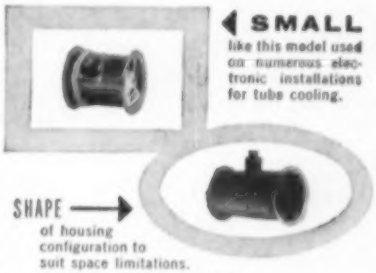
Another government research facility which provides useful data to the aircraft industry is the National Physical Laboratory of the Department of Scientific and Industrial Research (DSIR). NPL operates some 14 low-speed and small high-speed tunnels. Largest of the high-speed tunnels is 3 ft. by 1 ft. 2 in., capable of speeds up to Mach 1.8. A 2.6 in. by 1.5 in. continuous tunnel can operate up to Mach 4.

NPL plans to build an additional four small tunnels. Two are to operate up to Mach 4 and another up to Mach 5. The fourth, with an 8 by 8 in. working section, would have a range from Mach 5 to 10. It would be driven by direct discharge of compressed air to vacuum and be fitted with a heater to prevent liquefaction.

NPL also is proposing two shock

What's your blower problem?

BIG ▲ like this model used in the Stratocruiser



◀ **SMALL** like this model used on numerous electronic installations for tube cooling.

SHAPE → of housing configuration to suit space limitations.

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tubes, one with a 6 by 6 in. cross-section for study of supersonic flow and the other with a 20 by 20 in. working section for investigation of hypersonic flow.

To overcome the serious bottleneck in tunnel capacity, more than a dozen firms in the aircraft industry banded together in 1949 to form the Aircraft Research Association. Their first objective was to meet the need for a large tunnel in the transonic range, at the same time sharing the cost.

Contributions of the participating companies were in proportion to their interest in the tunnel. A company contributing one-tenth of the initial and running costs acquired a similar proportion of tunnel time.

The tunnel, opened last year at Bedford, cost $4.2 million. It has a working section 9 by 8 ft. which can take a flow of 1¼ tons of air per second for operation in the Mach 0.6 to 1.3 range. The two 20-blade, 20 ft. fans are driven by a 25,000 hp. motor.

Three other tunnels are under construction at the ARA site—a small transonic tunnel with a 9 by 8 in. working section, a Mach 3.4 supersonic tunnel with a 2¼ by 2¼ ft. working section, and a hypersonic tunnel.

Bristol Aircraft Facilities

Many firms also have struck out on their own in recent months, building not only wind tunnels but other research facilities.

Bristol Aircraft Ltd. now has three wind tunnels—a 20 by 15 in. supersonic tunnel for Mach 1.5 to Mach 3.5; an 8 by 6 ft. low-speed tunnel for 120 ft./sec. and a 12 by 10 ft. low-speed tunnel for 300 ft./sec. The firm also owns a one-fifth interest in the ARA tunnel.

Bristol's supersonic tunnel is one of the largest privately-owned tunnels in Britain. Unlike most other supersonic units, it is a simple blow-down type. This was determined by the fact that a convenient supply of high pressure air was at hand in the company's turbine test station. Since the tunnel exhausts into the atmosphere, hot air is employed, saving expensive cooling and drying installations.

Newest tunnel at Bristol is the low-speed 300 ft./sec. tunnel, which can take a model of 9 ft. span. Bristol found it needed the tunnel to study low-speed characteristics of high-speed aircraft.

A new high-altitude test plant at Bristol will make possible free jet testing for ramjets of any size foreseen at present in Britain. When this is completed, it will be comparable to the test cell at the National Gas Turbine Establishment and another installation going up at Rolls-Royce.

A new aero-engine test plant at Bristol is capable of testing engines up to 25,000 lbs. thrust and, with minor modifications, will take engines to 40,000 lbs. thrust.

De Havilland Gyron Test Bed

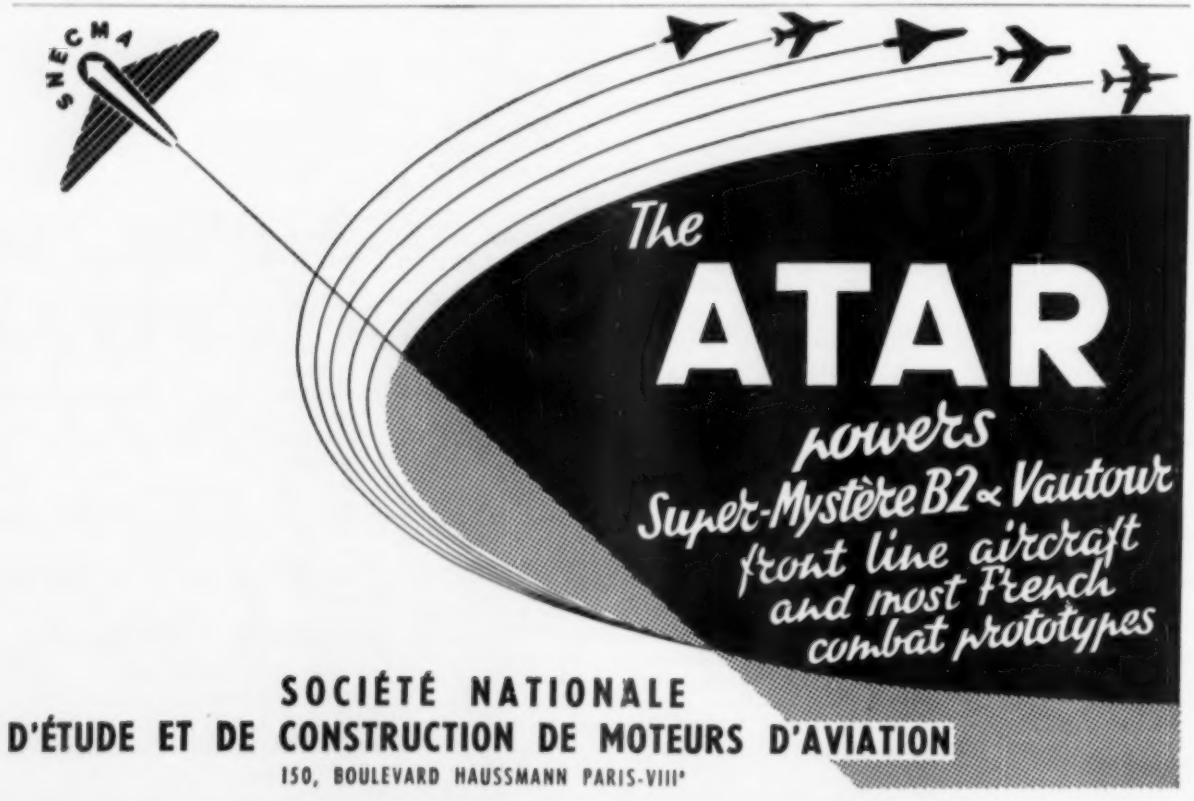
De Havilland's huge Gyron test bed is designed to handle engines of up to 30,000 lbs. thrust or more. It employs an unusual twin intake arrangement for a two-stage airflow. The main intake at the front of the building provides combustion air for the engine as well as some air for cooling; a second intake on the roof provides an additional mass of air for cooling, drawn in by the velocity of the exhaust gases.

De Havilland operates a Mach 1 to Mach 1.6 transonic tunnel with a 2 by 2 ft. working section, as well as a 9 by 7 ft. low-speed tunnel.

Rolls-Royce Altitude Facility

Rolls-Royce is investing $11 million in a high-altitude test facility for gas turbine engines. Full-scale testing is to begin at this 13¼-acre establishment next January. There will be two high-altitude test chambers, one for turbojets and the other for both turbojets and turboprops.

The company says these are designed to test the most powerful engines projected. The chambers will be some 75 ft. long and 12 ft., 6 in. in internal



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diameter. In addition to the main engine test cells, there will be a Mach 4 wind tunnel. When completed, this will be the only privately-owned high-altitude aero-engine test facility in the Commonwealth.

English Electric Tunnels

English Electric Co. is spending nearly $1 million to build two new supersonic wind tunnels. A Mach 4 tunnel for the aircraft division will have a 4 by 4 ft. working section and a Mach 6 tunnel for the guided weapons division will have an 18 by 18 in. section. The tunnels, to be in operation in 1958, will be the intermittent blow-down type, operating from a common compressed air supply.

The company also has one low-speed and two transonic tunnels. One of these, which started operation in 1950, was the first transonic tunnel in Britain.

Short, Vickers-Armstrongs

Vickers-Armstrongs carries out research and development work in three low-speed and one subsonic tunnel, in addition to employing such facilities as an altitude chamber for testing airframe components at heights up to 80,000 ft.

Short Brothers & Harland last year began tests with a transonic tunnel operating up to Mach 1.2. The firm also operates a low-speed tunnel and is installing an elaborate ground test facility.

One of the industry's newest centrifuges is installed at Napier. It can impose alternate positive and negative acceleration loads as high as 100 Gs. National Physical Laboratory has a centrifuge of 30 ft. radius capable of 100 ft./sec. circumferential speed.

Hawker Siddeley Group

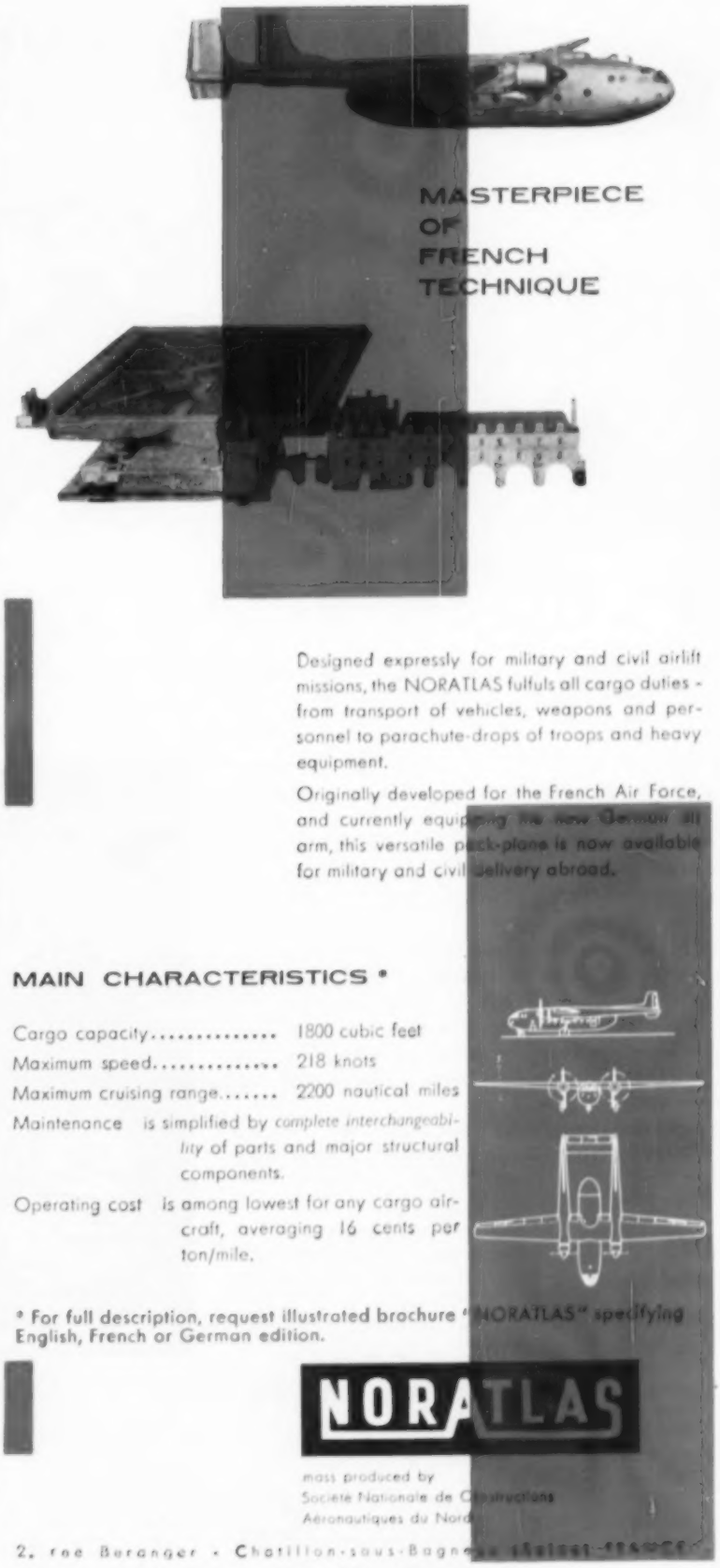
Some of the most extensive research and development facilities in Britain are to be found in the Hawker Siddeley Group:

• **Armstrong Whitworth Aircraft** is spending $2.8 million to establish a fully-equipped aircraft and guided missile research and design center at Whitley, near Coventry. The company last year opened a 10,000 hp. Mach 3 wind tunnel at Whitley, where it also operates transonic and low-speed tunnels.

• **Armstrong Siddeley's facility** for research and development work on gas turbines and rocket motors is near completion.

• **Hawker Aircraft is carrying** out the biggest expansion and rebuilding scheme in the 47-year history of the company, spending well over $3 million to expand research facilities.

• **Avro is completing** one of the few facilities in Britain for the study of thermodynamic problems. The firm also has added a Mach 3.5 intermittent wind tunnel to its low-speed and transonic tunnels. ■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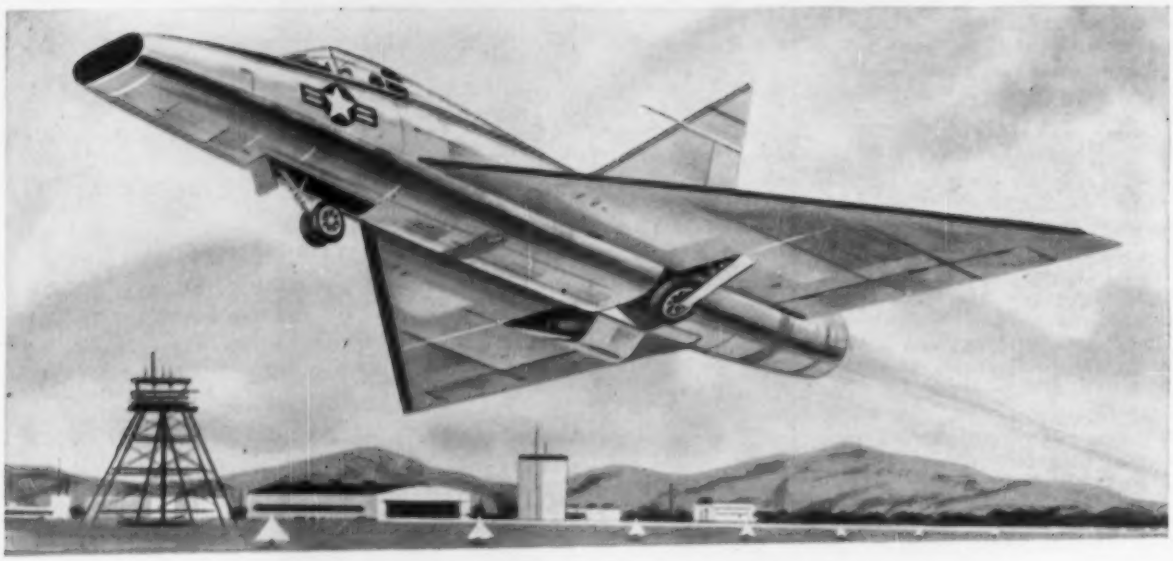

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PRESSURE.	Rated operating pressure 60 PSI. Max. internal leakage 10 DPM at 60 PSI
PORTS.	Per AND-10050-16.

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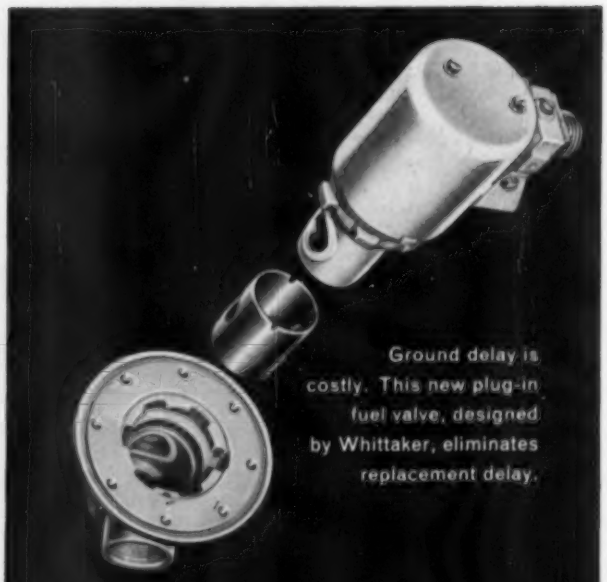

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Germany's Air Research Revitalized

By David A. Anderton

Aachen, Germany—Aeronautical research and development in Germany, brought to a shuddering halt by the end of the war just twelve years ago, is on the upswing under the leadership of one of the pioneering air research organizations, the Deutsche Versuchsanstalt Fuer Luftfahrt (DVL).

Reorganized two years ago, DVL is responsible for the major share of Germany's research contributions to Western air development. It now is scattered over six locations within the West German Republic, but hopes to concentrate the major part of its activities within five years at a new site now under construction at Essen-Muelheim.

Estimated total cost of the new facilities is 60 million Deutschmarks (approximately $15 million) spent for new construction and equipment over the next five years. With the new aeronautical center completed, DVL foresees an annual operating budget on the order of three million dollars and a personnel roster of about 1,000, approximately half of its wartime peak level.

Biggest task now facing DVL is its reorganization and re-establishment of its roots in buildings and facilities of some permanence. DVL's wartime home was Berlin.

Its facilities there went up in smoke or out in Russian trucks and its scientists fled in many directions. Today there is a small nucleus of the wartime group left—for example, seven of the wartime chiefs of DVL are here at Aachen—but the majority of the scientists are of the next generation that spent the war years in other activity.

Typical of DVL's research activity are these examples that have excited considerable interest abroad:

• **Pressure distribution surveys** have been made on compressor and turbine blades using an elaborate system devised here. The blades have seven survey stations along their span and at each station there are 20 pressure taps, for a total of 140 points per blade. Pressures data is transmitted out to recording equipment. Currently the studies are concerned with steady state conditions, but will be extended in the future to cover such transient phenomena as the rotating stall.

• **Efficiency of a supersonic** two-shock diffuser of the type developed by DVL's Klaus Oswatitsch during the latter years of the war has been increased measurably by the addition of a cowling ahead of the inlet. This cowling, which extends upstream of the central spike in the diffuser generates a conical wave front which intersects the conical wave front off the nose spike. A gap between the cowling and the normal inlet of the diffuser acts as a regulator of mass flow by making spill of the excess flow possible. Plots of pressure recovery against flow ratio show a nearly flat curve for the cowled inlet, contrasting sharply to the peaked recovery curve for a standard spiked inlet. The diffuser also operates without buzzing.

DVL's current facilities are few. Here at Aachen there is a supersonic wind tunnel of the blowdown type, operating from a 120 hp. compressor rig and using a heat exchange to raise the air temperature ahead of the test section.

This tunnel has nozzles for Mach 3 and Mach 6 and a maximum duration of 30 seconds per run. Compressor capacity limits the runs to two per day.

At Essen-Muelheim there is a structures laboratory with a large test area about 200 by 100 ft. capable of static testing a structure as large as the wing of a Lockheed Super-Constellation. Also at Essen is the airport where now DVL works in connection with the German Ministry, doing technical calculations and other associated work for the certification of new aircraft.

Plans for future facilities include construction of a 10-ft. throat transonic wind tunnel, a series of test stands for jet engines of all types, and the construction and equipping of laboratories for avionics, materials, fuels and lubricants, control and steering techniques and aviation medicine.

DVL is a private organization laid out along the lines of corporate structure. Its financial support, because of the present state of the German aircraft industry, comes mostly from governmental agencies.

Heading the organization chart is a long list of cooperating agencies and individuals, both in private and public life.

Actual direction of the DVL begins at the next level with a survey board composed of representatives of German industry, governmental and educational institutions. Below that group is a five-man administrative group that provides direct supervision of the research programs.

There are four institutes within the framework of DVL:

• **Airframe,** which includes applied gas dynamics, theoretical gas dynamics, turbulence research, flight mechanics and structures.

• **Powerplant,** which includes thermodynamics and combustion jet engines, powerplant dynamics and fuels and lubricants.

• **Materials section** located at Aachen, which works on problems common to both powerplant and airframe regimes and is therefore carried on the organization chart as common to both.

• **Avionics,** which includes microwave techniques and flight communications.

• **Special problems,** which includes flight medicine, steering and control, and documentation. ■

Italian Research Is Specialized

Rome—Human factors and optics are two of the specialized fields in which Italian researchers are making major contributions to aviation research and development.

Current studies in these areas are being financed in part by the Brussels office of the Air and Research and Development Command.

These highly specialized scientific disciplines are indicative of the kinds of European research being conducted at universities and technical institutes on the continent.

Italian research in aeronautics follows the traditional dual path, where basic problems are studied in universities and applied research is generally the task of industry. University research in the field of aircraft and propulsion is done predominantly in the aeronautical engineering schools of three universities, Rome, Milan and Turin. Each of these schools has divisions with specialized tasks of instruction and research, although the major amount of effort and manpower is expended in teaching rather than in problem-solving.

Giant in industrial aeronautical research and development is Fiat S.P.A., whose aviation division in Turin is equipped with an outstanding series of mechanical, physical and chemical laboratories. Structures laboratory—where now the charred and bent body of the prototype Fiat G91 is reassembled on wooden props—has several strongback setups for structural tests of complete aircraft. ■

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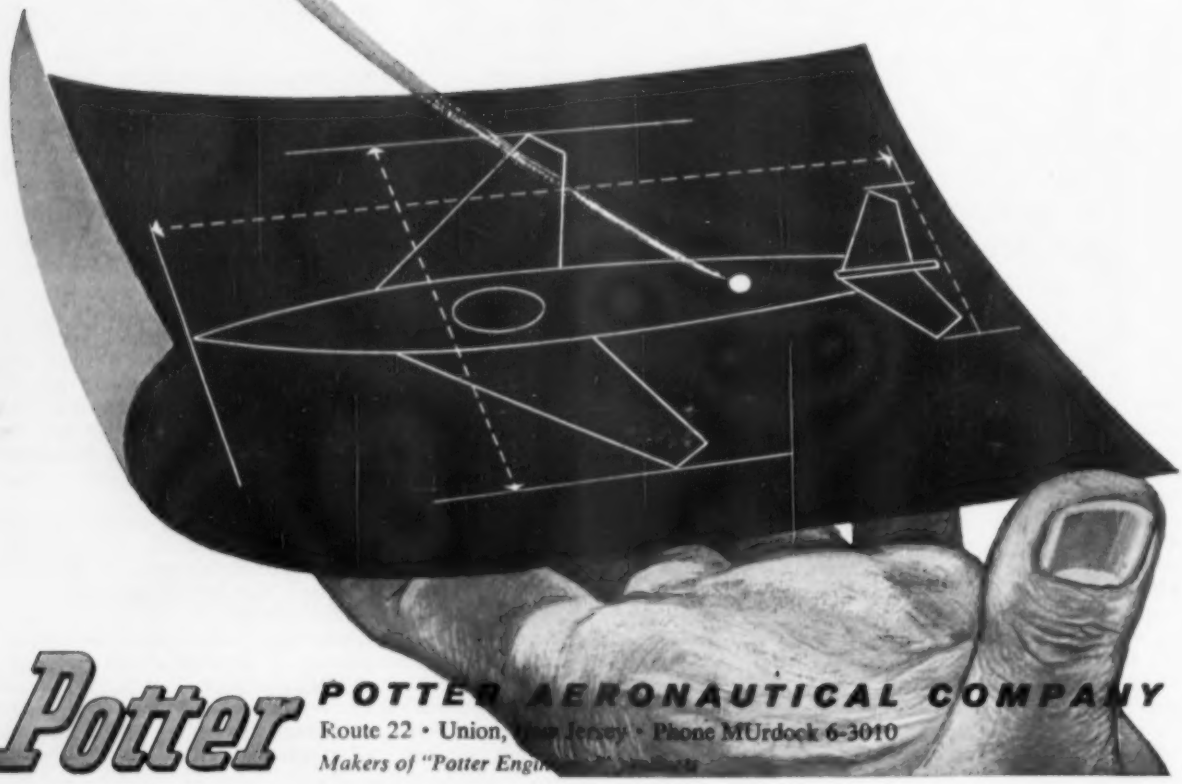

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DELTAVIEX interceptor in open-circuit tunnel. Built by old Ouest Aviation, it uses supercirculation for high lift.

French Research Now Leads Industry

Paris—French research and development in aviation, sometimes hampered since the end of the war by mistakes, lack of funds and a lack of interest among government officials, now is keeping well ahead of industry's demands.

Postwar aviation achievements include Mach 2-plus rocket powered and ramjet powered fighter prototypes as well as the twin-jet Caravelle transport. Although the French research and development effort still is lacking in funds, it is efficient and alert.

ONERA Is Key Agency

Biggest portion of France's research and development work is carried out by the Office Nationale d'Etudes et de Recherches Aeronautiques, located at Chatillon on the outskirts of Paris.

Director of ONERA is Maurice Roy.

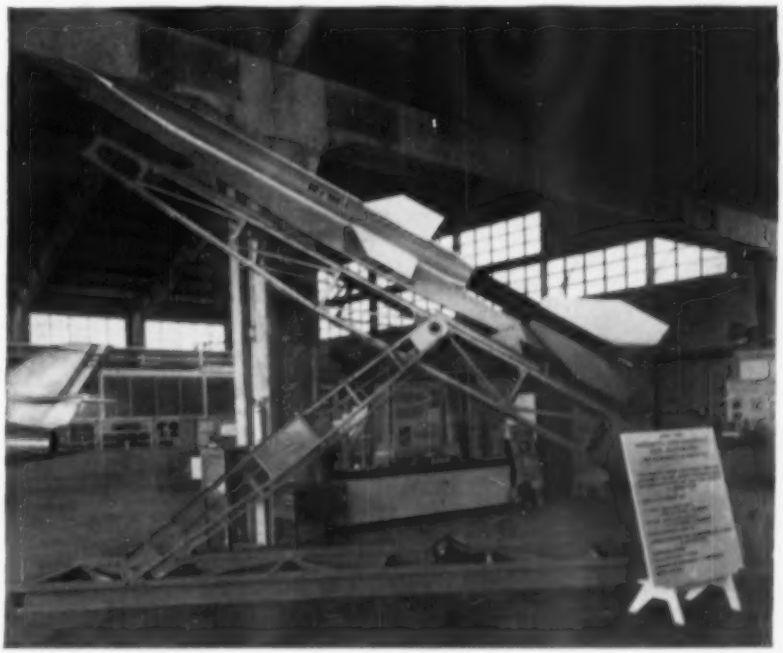
ONERA was created in 1946 to support industry's needs in the research and development fields. Although most companies maintain important research bureaus and even operate some facilities, ONERA does the bulk of the investigating. ONERA's program is closely controlled by the Direction Technique et Industrielle de l'Aeronautique, which is a branch of the French Air Ministry.

ONERA operates 15 wind tunnels, the most important in Europe, and now is building four more. It employs about 2,000, including 500 research engineers.

In addition to the efforts of individual aviation firms and ONERA, a great deal of research is done by universities—some of it pure research, but much of it also on contracts from companies or from the government.

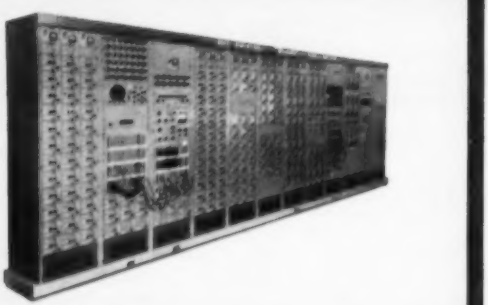
Important research on the Caravelle design, for example, was done by the Institue d'Aerotechnique de Saint-Cyr, an organization which dates back to 1909.

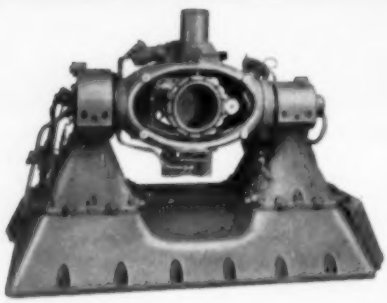
Almost all guided missile research in



TWO-STAGE OPD 320 research rocket reaches Mach 2.5, is recoverable by parachute.

Bendix flight simulators reduce the risks





The hazards of missile testing can be materially lowered when performance is checked out on-the-ground with a BENDIX 3-dimensional Flight Systems Simulator, prior to take-off. Comprised of two basic units—a flight table and an electronic analog computer—the BENDIX-built Flight Simulator will foretell complete operating programs from launching pad to target, for rockets, ballistic and guided missiles and jet aircraft. It catches bugs without expensive trial flights, materially reduces guesswork and adds a valuable safety factor at both ends of the test shot. *For complete technical data, mail the coupon.*

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France is carried out by the Laboratoire de Recherches Ballistiques et Aerodynamiques at Vernon. It is an agency of the French Defense Department, and very little information on missile work is released.

The Laboratoire operates all its own testing facilities, including four wind tunnels, one of which operates over a speed range up to Mach 6.

Five Modane Tunnels

Showplace of French aeronautical research is ONERA's establishment at Modane-Avrieux in the French Alps. ONERA's Aero and Thermodynamic Testing Establishment has been operating a 110,000 hp. tunnel, designated S,MA for three years, and four other tunnels are under construction.

The S,MA was made transonic in 1955. Working section is 8 meters in diameter and air flow can be made visible. Example of the kind of practical testing that can be done is the jettisoning of cockpit canopies in air speeds of 500 mph.

A 60,000 hp. continuous flow supersonic tunnel, designated S,MA now is being built. In 1958, three other economical supersonic tunnels of the intermittent type will come into service. They are designated T1, T2 and T3 and when they are completed they will provide facilities for testing over a range from Mach 0.9 to Mach 5.

Visualization Techniques

In visualization of airflow as well as in interpretation of aerodynamic phenomena, ONERA has done new work in the use of stroboscopes for the observation of shock waves; viscous fluid for showing up zones of disturbance; and studies on the breakup of airflow and flow reversal on model surfaces.

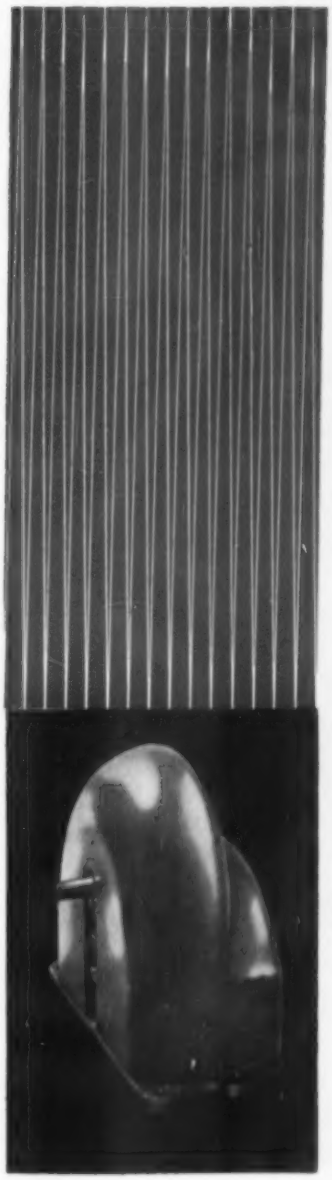
In its hydrodynamic tunnel ONERA has used colored jets to help in the visualization of surface flow.

ONERA claims to have achieved considerable success with boundary layer control work and "pneumatic piloting," a form of circulation control that might do away with ailerons and other movable control surfaces.

The agency has been using a Breguet Vultur 960-01 for the tests. This aircraft, a forerunner of Breguet's 1050 anti-submarine carrier plane, is powered by a Hispano-Suiza Nene turbojet which has been adapted to blow compressed air through injectors to control the boundary layer on the flaps.

For the past three years emphasis has been on finding methods for controlling and activating the circulation and airflow over a wing by the projection of jets of air at the trailing edge.

Carried into the supersonic regions, this "pneumatic piloting" may someday eliminate ordinary control surfaces, ONERA believes. ■



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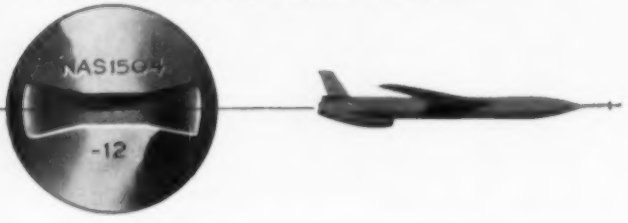

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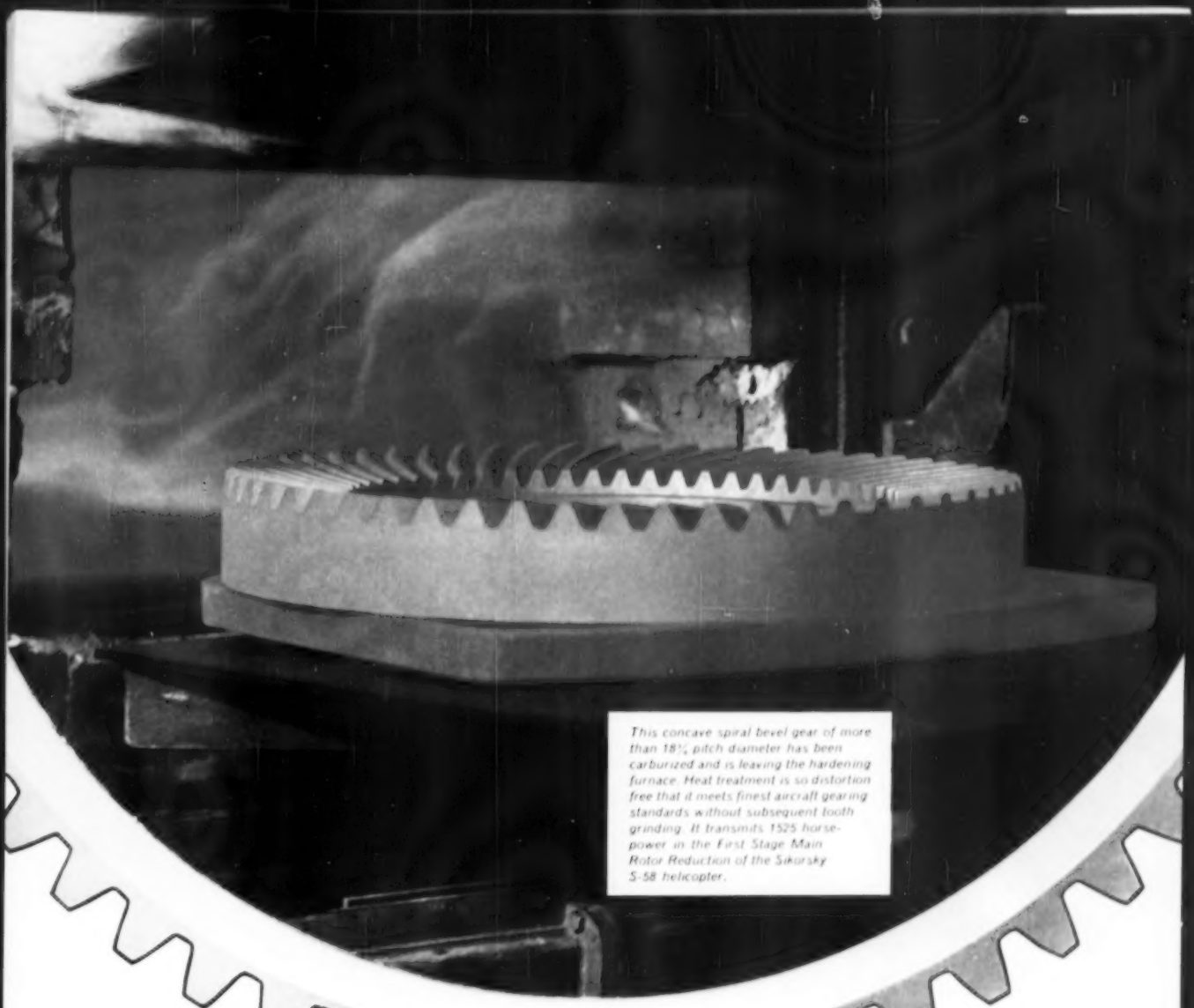

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The Boeing B-52D Stratofortress is an eight-jet, swept-wing, U.S. Air Force long-range heavy bomber now in production by Boeing. Wing span, 185 ft. Overall length, 156 ft. Tail height, 48 ft. Sweepback, 35 deg. Gross weight, over 400,000 lbs. Powered by eight Pratt & Whitney J57 turbojet engines, each rated in the 10,000 lb. thrust class. Boeing-developed "Flying Boom" aerial refueling gives the B-52D virtually unlimited range beyond the specified more than 6000 miles. Speed, 650 m.p.h. Service ceiling, over 50,000 ft

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Individuals Spark Swiss Air Research

Geneva—Natural curiosity of a handful of scientists accounts for the major share of aeronautical research in Switzerland.

These men, Eidgenossische Technische Hochschule (ETH), also direct the research work of the Institute associated with ETH.

The dozen or so scientists at ETH thus serve the dual purpose of teaching and practicing research. They are assisted by small permanent staffs. Rest of the research group is likely to be made up of candidates for doctorates in science.

Dean of the group, and one of the top aeronautical scientists of the world, is Prof. Dr. J. Ackeret, whose specialty has traditionally been the exploration of subjects which are likely to become problems in the next decade of aeronautical development.

In recent years his interest has been turned to thrust reversers for jet engines.

His latest idea along that line uses a swirler in the center of the jet to spin the exhaust blast. Centrifugal force generated by the spin spreads the blast and it impinges on annular vanes which turn it. When not in use, the reverser is far enough away from the jet exhaust to produce no effect on the engine.

Working parallel to Ackeret's Institute for Aerodynamics is the Institute for Airframe Statics and Construction, headed by Prof. Dr. Manfred Rauscher, formerly of Massachusetts Institute of Technology.

In addition to this, the group—as in the other institutes—does consulting work for the Federal Aircraft Factory at Emmen, and before the war developed an STOL airplane called the Pellikan. Krauscher has two Americans—Bisplinghoff of MIT and Houbolt of NACA—working on doctorate thesis in his institute.

Strongest tradition of fatigue research—extending over the past twenty to thirty years—is at the Eidg. Msterisl-pruefungsund Versuchsamt, another Swiss federal agency that corresponds in some extent to the U. S. Bureau of Standards.

Largest of the industrial research and development organizations in aviation is that maintained by the Eidg. Flugzeugwerk Emmen (Federal Aircraft Factory at Emmon). Even though most of the limited amount of Swiss aircraft production is done under its order at other locations, Emmen accounts for a great part of the research and development aimed at getting the answers to specific questions on development aircraft.

The company's wind tunnels cover the speed range from zero to 2,800 mph.

Subsonic tunnels operate at speeds below 180 mph. Larger of the two has a test section about 23 by 16 ft. Size of the smaller is about 8 by 6 feet. The transonic tunnel covers the speed range from Mach 0.5 to 1.2. Test section size is about 2 feet by 1.6 feet. Powerplant for the transonic tunnel is a pair of Rolls-Royce Nene turbojets.

Eleven by 11-in. supersonic wind tunnel has a speed range from Mach 1.5 to 3.8. Jet engine test stand can handle engines under sea level conditions up to an air capacity of about 90 lb. per sec. with ram air at about 350 mph.; with smaller air capacity of about seven pounds. Altitude capability of plant can be raised to about 36,000 ft. ■

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ENGINEERS and SCIENTISTS

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Artist's conception of how a nuclear propulsion plant for aircraft might be installed. Special shielded vehicle protects installation crew from stray nuclear rays. This illustration was part of exhibit of G.E.'s Aircraft Nuclear Propulsion Dept. at International Atomic Exposition held March 11 to 15.

General Electric is now branching out into the second stage of its extensive program for nuclear powered flight. The first was reached successfully only a short time ago, when the first turbojet to be exclusively powered by heat from an atomic reactor was ground tested at the National Reactor Testing Station in Idaho.

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AGARD Is Research Data Exchange

Paris—AGARD is a study in the communication of aeronautical research. It owns no facilities, operates no wind tunnels, flies no airplanes. Yet through its efforts the member nations of NATO have benefited to an indefinable extent through the mutual exchange of research information.

During its five-year life, AGARD has been responsible for the widest variety of tasks. A special panel evaluated the competing designs of three light fighters planned around a SHAPE specification.

Members of the secretariat interested Turkey in operational research techniques to enable them to make better use of their defense forces.

Because of AGARD, Greece has an altitude chamber for pilot selection, Norway has better solid propellants for rockets, and Italy knows more about titanium. A monumental treatise on flight testing in four volumes and 2,000 pages was prepared by an AGARD panel to aid NATO flight test engineers in their planning of programs.

Perhaps most remarkable is the fact that this work has been done with only the smallest of permanent staffs—the secretariat—and a handful of scientists from NATO countries who serve on one of AGARD's six panels.

AGARD stands as an outstanding example of the importance of knowing where and what kind of aeronautical research is being done, and the fastest way to communicate the results of that work to others.

AGARD'S Main Objectives

AGARD, which stands for Advisory Group for Aeronautical Research and Development, is a part of the North Atlantic Treaty Organization, under the Standing Group of the Military Committee. Its original charter suggested four major objectives:

- **Continuous review** of the possible applications of advances in aeronautical science to common defense problems.
- **Recommendations for improved** cooperation in aeronautical research and development among the member nations of NATO.
- **Recommendations for the solution** of problems referred to AGARD by NATO agencies, including evaluations of specific research and development projects.
- **Exploration of methods** for improving the exchange of information about aeronautical research and development.

Supported logistically by the United States Air Force during the first two years of its existence, AGARD now is funded from NATO's budget. Annual operating budget is 100 million francs—less than $290,000—and out of this small amount comes the salaries of the secretariat, consultant fees, travel, the expenses of meetings and the publication program.

Dollar for dollar, AGARD probably is the source of the biggest return of any NATO investment.

Elected chairman of the organization is Dr. Theodore von Karman, whose name alone is a guarantee of scientific responsibility and respectability. But everyone who knows von Karman knows also that he is more than a figurehead.

His first contribution to AGARD was a delineation of the major areas where the organization could make specific contributions. This was not an easy task because the areas staked out for research had to be those where research was needed and yet where the results of that research could be freely communicated without the need for tight security.

Six Panels Monitor Research

There are, as a result of the original meeting of the AGARD group and von Karman's thoughts, six panels of the organization—Aeromedical, Combustion and Propulsion, Documentation, Flight Test, Structures and Wind Tunnel.

Each is headed by a chairman and a deputy chairman chosen from the delegates of the NATO countries to AGARD. Under the chairman level is an executive, stationed in Paris as a member of the Secretariat. Panel membership varies but is under 20 delegates per panel.

Main job of the panels is not necessarily to do the specific work needed, but to know where that work is being done, or to stimulate someone to do the work. Thus AGARD is not of itself a research organization, but rather a supercoordinator of scientific research and development.

Examples of AGARD's Work

An outstanding example of the way a panel works is the case of the flight test manuals, prepared under the aegis of the Flight Test Panel. The first volume of the four is devoted to performance of airplanes in flight, and was written by more than 20 leading flight test pilots and engineers of the NATO nations.

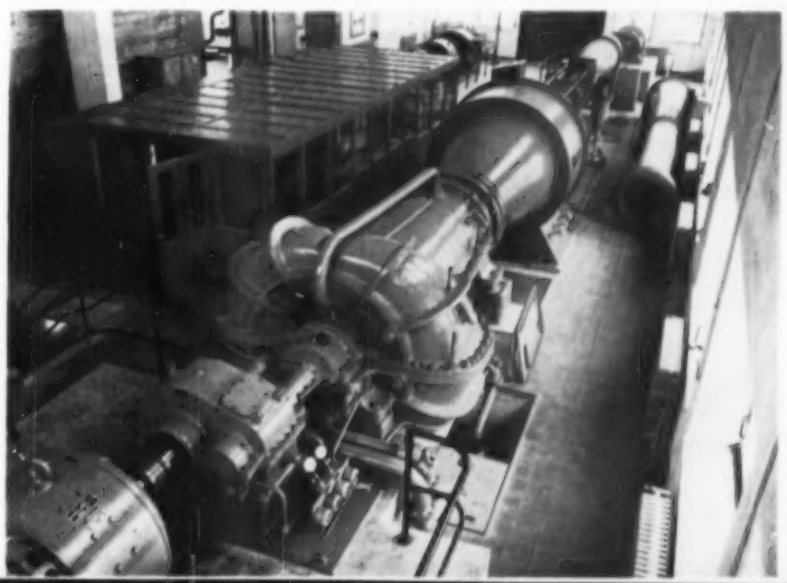
Their chapters covered everything in the field of performance, test techniques, data reduction methods and methods for flight test analysis. In a like manner, aircraft stability and control was thoroughly dealt with in the second volume.

Perhaps the most unusual of the volumes is the third, which is a catalog of flight test instrumentation that has been used successfully by engineers and pilots of the NATO countries. Instrumentation included here is not confined merely to commercially available, off-the-shelf items. Listings include one-of-a-kind gadgets built to solve a specific problem in the Netherlands or France or the United States.

Cost data, availability of drawings and the like are given as part of the catalog information, and the whole book is sectionalized by the functions of the instruments. If a flight test engineer wants a stick-force indicator, that is the subject heading he looks for in the manual.

Fourth volume in the series is devoted to instrumentation systems, categorized by type of data desired. ■

SUPERSONIC wind tunnel at AGARD's aeronautical training center in Belgium.



Japan Gradually Reentering Air Age

By Dan Kurzman

Tokyo—Japan, whose air force, aircraft industry, and air-mindedness vanished in the wake of Hiroshima, is gradually reentering the air age.

It is experimenting with basic missiles, drawing up transport aircraft designs, and planning to produce shortly Japan's first post-war jet plane—a light trainer.

But progress in aeronautical research and development must be made in defiance of many obstacles:

- **A lack of top-rate technicians** due to the long post-war absence of an aircraft industry and a general psychological aversion to all things associated with airpower.
- **Low demand for aircraft,** with the Japan Air Self-Defense Force and Japan Air Lines still in their infancy and private organizations and individuals buying cheaper foreign planes.
- **The poor financial conditions** of Japan's resurrected aircraft companies, which haven't the capital to put into large-scale research and development.

Nevertheless, Japan's plane makers are optimistic about the future. They believe the people will gradually develop a new interest in aeronautics that will clear away these obstacles and accelerate growth of the nation's aircraft industry.

At present, six private companies, five government institutes, and four universities are laying the groundwork for such advancement.

Fuji Heavy Industries

This company is now preparing for production of post-war Japan's first domestically designed jet plane—the T1F1 light jet trainer (wt. 3,300kg.). Three models—two prototype and one proof-test—will be built for the Japan Air Self-Defense Force. First prototype is scheduled for flight testing before the end of 1957.

First engine will be a British Bristol Aircraft Orpheus Mk. 1 engine which will permit a thrust of 2,600 lb. Later it will be replaced with a Japanese design now being developed by the Japan Jet Engine Co.

Under the Defense Agency contract, 370 million yen (approximately $925,000) will be spent on production of the three planes, including part of the cost of research and development. With Fuji's share of the cost added, 200 million yen in all will have been spent purely on study and experimentation from last summer to the end of 1958.

About 450 million yen is budgeted for new facilities for this development from last September to next August. This includes cost of machines for quality control and production and of construction of a 93,000 sq. ft. factory and a 17,000 sq. ft. building to house a new engineering department. Another 400 million yen will be spent on new machines and facilities when mass production starts in late 1959.

Kawasaki Aircraft

In the next five years, this firm will spend one billion yen on aeronautical research and development, 940 million yen on new facilities. Emphasis is on rocket development. Kawasaki successfully tested a KAM-1 aircraft-type missile in May, 1956. Purpose was to develop a solid propellant booster, permit study of a zero length launcher, and determine stability of the missile after start of flight.

Span and length of the missile: 3 ft.; thrust, 60 kg.; duration of flight, 1.5 sec.; maximum speed, 40 meters per sec. It has a rocket booster engine and carries a self-recording instrument to obtain acceleration and pitching angular velocity.

A more advanced aircraft-type rocket—the TM-B—will be tested in September, with attention centered on the aileron buzz at supersonic speed, telemetering, aerodynamic elasticity, and maneuverability and stability. Dimensions are: length 2 meters; span, 1 meter; weight, 50 kg.; speed, Mach 1.0; duration, 3 sec.; thrust 500 kg. A 10 kg. solid propellant outer surface burning engine is now being developed by Kawasaki for use in the rocket. This engine, which will have a double base of nitrocellulose and nitroglycerin, will be completed in about four years.

Research on a system of homing and guidance will start shortly after the September test if it is successful.

Kawasaki also has been conducting aerodynamic research on a one meter-long anti-tank guided missile for the Defense Agency since last fall. Six other companies, including Fuji Precision Machinery, Mitsubishi Electric, and Nippon Electric, are involved in the project. It is hoped that completion will come in two years. Paper research is finished and actual experimentation now is in progress.

Aircraft research is in a more basic stage than missile study. Designs of a supersonic jet fighter now are being drawn up, with something like an improved F-104 in mind. Experimentation is expected to begin next year.

Research facilities to be set up this year will include testing and measuring equipment for the missiles and a liquid rocket motor.

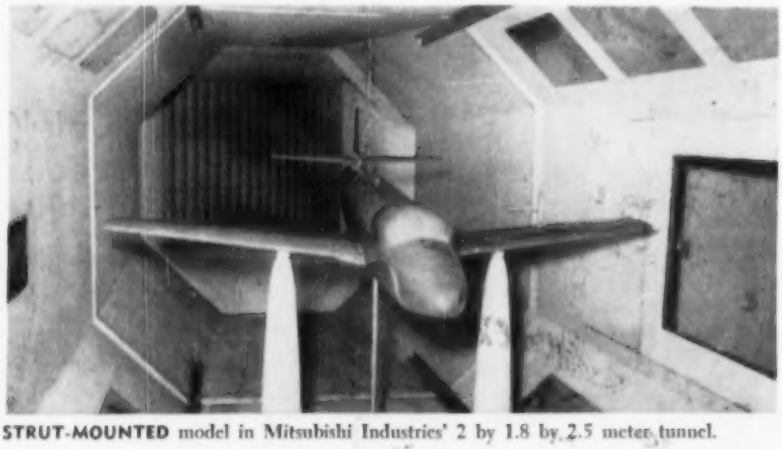
Mitsubishi Heavy Industries

This concern is spending 12.4 million yen from April 1956 to August 1957 on rocket research and development and more than 30 million yen on study of new aircraft in 1957.

About 2.4 million yen is being spent on the TMB-O missile. It uses a command guidance system, has a range of three kilometers, can climb to 350 meters with a speed of Mach 0.4. The 1.8-meter body has a one-meter wing and is propelled by a solid-propellant engine. The TMB-O will be used for the study of techniques and devices of homing and radar control.

First flight test of this rocket failed recently, believed due to a faulty catapult, but a second test will be held soon.

Ten million yen is being devoted to development of the TMA-1 test air-to-air guided missile, which is scheduled



STRUT-MOUNTED model in Mitsubishi Industries' 2 by 1.8 by 2.5 meter tunnel.

to be test-fired this summer. It is composed of a nose part 1.8 meters long, 40 kg. in weight, and 150 mm. in diameter, and a tail part 1.3 meters long and 70 kg. in weight. Maximum speed is Mach 1.6.

Mitsubishi also has started designing a supersonic jet fighter, with paper work expected to continue through 1959, manufacture of a prototype scheduled for 1960-61, and actual production time-tabled for 1961-63. Its maximum speed will probably be Mach 2-3.

New research and development facilities include a small wind tunnel with a diameter of two meters and a maximum speed of 100 meters per second to test the TMA-1.

Shinmeiwa

This firm has spent 15 million yen in the last year and a half and will spend another 15 to 20 million yen in Fiscal 1957 for research on a short-range transport plane (50-500 miles). Sixty per cent of the preliminary design is completed.

The aircraft will have turboprop engines, though it has not been decided yet whether it will have two or four. Gross weight will range from 15 to 25 tons, capacity load from 30 to 50 passengers. The plane will have high wings and will be equipped with a special high lift device. Metal bonding will be used for the structure.

Shinmeiwa claims it could start production in four years if there should be a demand for the plane.

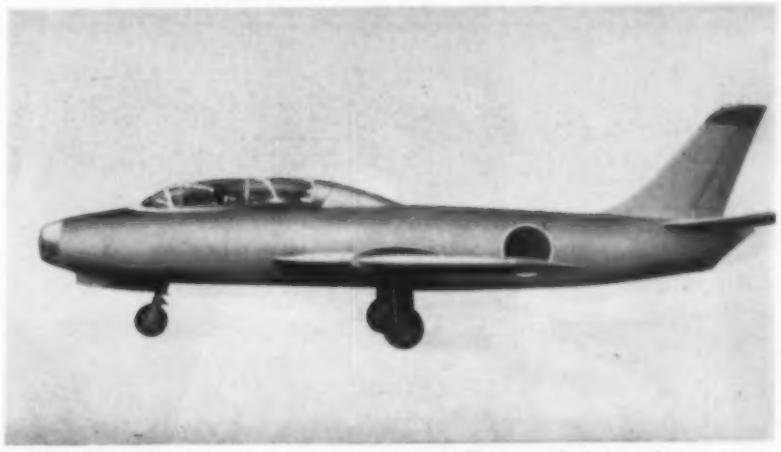
This company also is conducting research on a new flying boat whose load carrying capacity would exceed that of American-designed models by 30 to 50%. Five million yen was devoted to the project in 1956, and another five million will be spent in 1957. Designs will be completed by the end of the year.

Present facilities include a small water tank for low-speed testing of flying boat hull hydrodynamics and structural test equipment. The company now is preparing to construct a circular water tank for high-speed testing of flying boat hull hydrodynamics and a wind tunnel.

Fuji Precision Machinery

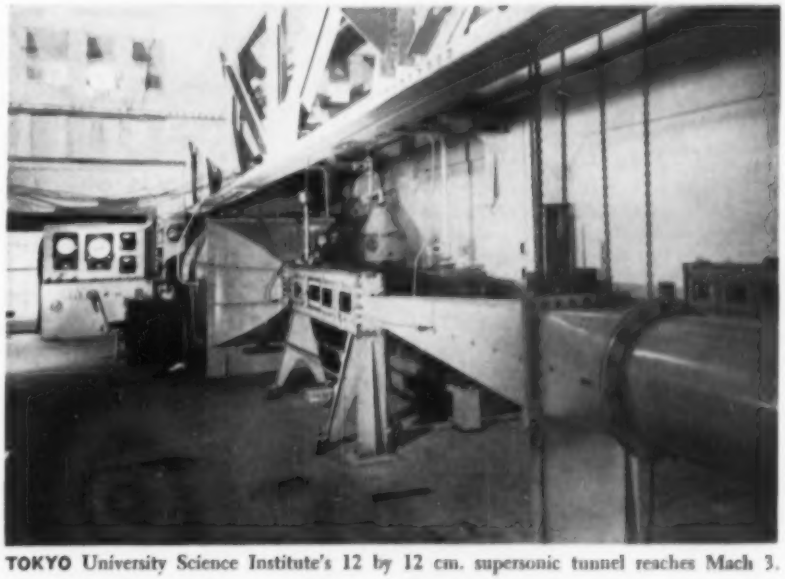
This company has been working on a solid propellant rocket engine since December of 1953 for use during the International Geophysical Year. Three engine models—Pencil, Baby, and Kappa types—already have been tested, and a fourth—an Alpha type—will be tested soon. The rocket body is being developed and tested at Tokyo University. Manufacture of the rocket as a whole will be done by Fuji Precision Machinery.

An air-to-air solid propellant rocket also is being developed for the Defense

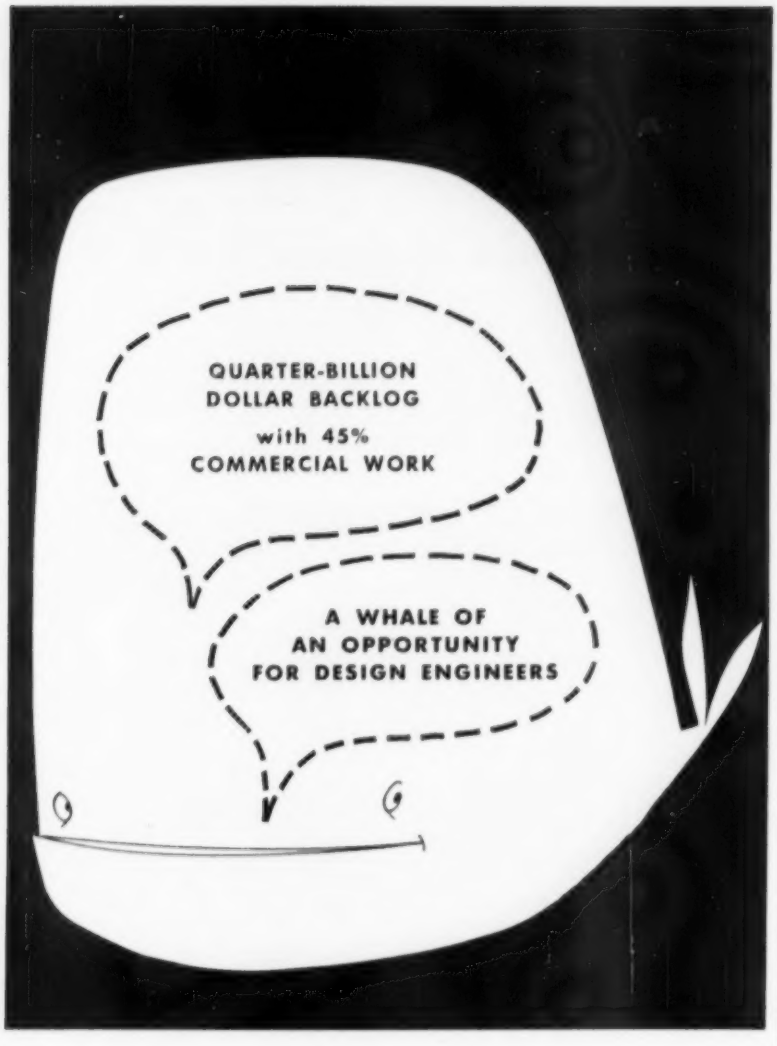


MOCKUP of Japan's first postwar aircraft, the Fuji T1F1 intermediate jet trainer.

TWO METER wind tunnel at Tokyo University's Institute of Science and Technology.



TOKYO University Science Institute's 12 by 12 cm. supersonic tunnel reaches Mach 3.



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Agency. Experimentation, which began a year and a half ago, is in an advanced stage and a flight test will be held soon. Basic research on an AAM guidance rocket has been in progress for a year, research on the Defence Agency anti-tank rocket for six months.

Among present facilities are 10 stands and three cells for testing rocket engines, and special machine tools. This year, three stands and one cell for larger rockets with thrusts up to 50 tons will be installed.

Nippon Jet Engine

Established in 1953 to conduct research on and manufacture prototype gas turbines, this firm (capitalization: 220 million yen) is jointly owned by five companies: Fuji Heavy Industries, Kawasaki Aircraft, Mitsubishi Heavy Industries, Reorganized; Fuji Precision Machinery, and Ishikawajima Heavy Industries.

It has completed two small turbojet engines for the Defense Agency—the JO-1 in 1954 and the J3-1 in 1956. The J3-1 has been on the test bed since September and will be ready for installation in the Fuji T1F1 jet trainer by the end of the year.

The company has few facilities, since member companies primarily use their own.

Nippon does have machine tools for manufacturing turbines and compression blades and a small cascade wind tunnel.

Medium Transport Research

The Society for Research on Medium-Size Transport is another joint organization among whose members are Fuji Heavy Industries, Kawasaki Aircraft, Mitsubishi Heavy Industries, Reorganized; Shinmeiwa, Showa Aircraft, and Nihon Hikoki. Inaugurated in May 1957, this group has launched a five-year program for the production of medium-sized commercial airliners for domestic or Southeast Asian service. The first two and a half years of the plan will be devoted to preparatory study and designing. The last half of the program calls for experimental production and flight testing.

About 200 million yen will be spent on basic research in the initial period. Of this, 90 million yen is to be expended in Fiscal 1957—35 million yen by the government, the remainder by the member companies. The plane will weigh 15,000 kg. and be equipped with four 2,400-2,600 hp. turboprop engines. It will cruise at 300 mph. and have a range of less than 1,000 miles. Load capacity will be 30 to 40 passengers.

Technical Research Institute

Research expenditures by this institute, which is a part of the Defense

Agency, were 550 million yen in 1956, will jump to 740 million yen in 1957. Part of this will go for research on airframe accessories, engine parts and accessories, and electronics in connection with the T1F1 light jet trainer and its jet engine. Another part is going for experimentation on a new target plane, a prototype of which will be completed this year.

Research also is in progress on boundary layer control and a device for shortening the take-off and landing run, with actual experimentation on both scheduled for next year.

Facilities, including those under construction, are available for testing aircraft structure, landing gear, jet engine, airframe and engine accessories, and electronic equipment. In addition, an overhauled wartime supersonic wind tunnel for testing missiles (diameter, 0.3 meters; maximum velocity, 70 m./sec.) and target plane test facilities soon will be established.

National Aeronautical Lab

This laboratory, part of the Science and Technology Agency, spent 400 million yen on construction of research facilities last year, will invest in the next two years two billion yen for construction of a new subsonic wind tunnel and installation of various airframe structure test equipment and other facilities.

Work on the wind tunnel started last fall, will be completed in 1959. Its size is 2 by 2 meters; speed, Mach 1.3. Construction of a small flutter wind tunnel also is underway.

A supersonic wind tunnel will be built when the other tunnels are completed.

The laboratory also is setting up test facilities for the jet engine and its parts, which may be in operation by next spring.

More Research on Trainer

The Transportation Technical Research Institute of the Ministry of Transportation will spend about 25 million yen this year on airframe and jet engine tests and research on a gas-turbine compressor, turbine rotor, and numerical weather forecast. Most of the study will be conducted in connection with the new Fuji jet trainer.

Research on subsonic aircraft has been in progress since 1952 with the use of a wind tunnel 1.0 by 1.8 meters, capable of a velocity of 40 meters per sec.

High subsonic speed tests will be possible this fall when a newly-repaired wind tunnel with a diameter of 0.5 meters and maximum velocity of 335 meters per second is ready for use.

Other existing facilities include a flutter test wind tunnel and repaired ex-Japanese navy landing gear test equipment.

This laboratory, part of the International Trade and Industry Ministry, will spend more than 50 million yen this year for basic research on aerodynamics, turbojet engines, aircraft structures, new materials, turbine blade cooling, blade flutter, and lubrication oil and jet fuel.

Now ready for use is an old but repaired subsonic wind tunnel 1.8 meters by 2.2 meters with a maximum velocity of 260 meters per second. It can be used for supersonic tests if supplementary equipment is attached.

Electro-Technical Laboratory

Electronic research related to aircraft-ground communications is now being conducted by this laboratory, also a part of the Ministry of International Trade and Industry. A total of 3.6 million yen was spent in 1955 and 1956 for study of a ground control interceptor, and 1.8 million yen will be devoted to this project in 1957. Another 5.4 million yen will be spent this year on attempts to adapt the pulse technique to wireless communications for use in aircraft and for missile control.

The laboratory is planning to spend 576 million yen in 1957 on new electronic test equipment, including high frequency measuring equipment, mechanical environmental test, electrical equipment, and electronic components —about half of this to come from the U. S., half from domestic factories.

University Research

Tokyo University's Institute of Science and Technology will spend about five million yen this year, the same as in 1956, on basic research on transonic and supersonic aerodynamics, airplane structure and materials, and jet engines. It is testing the T1F1 jet trainer with Japan's most reliable transonic wind tunnel (30 by 30 cm., Mach 1.1).

A supersonic wind tunnel (12 by 12 cm., Mach 3), to be completed this summer, will be used for high-speed boundary layer study.

At Tokyo University's Institute of Industrial Science, development of the body of the observation rocket to be used in the Geophysical Year is well underway. About 100 million yen was devoted to this project last year, and 150 million yen will be spent on it this year. The two-stage Kappa rocket (diameter, 8 cm.; length, 2 m.; max. altitude, 100 km.) has been tested successfully, and the final three-stage rocket is nearing completion.

Three other universities—Kyoto, Nagoya, and Kyushu—only recently inaugurated aeronautical departments and are engaged in basic theoretical research on aerodynamics. ■

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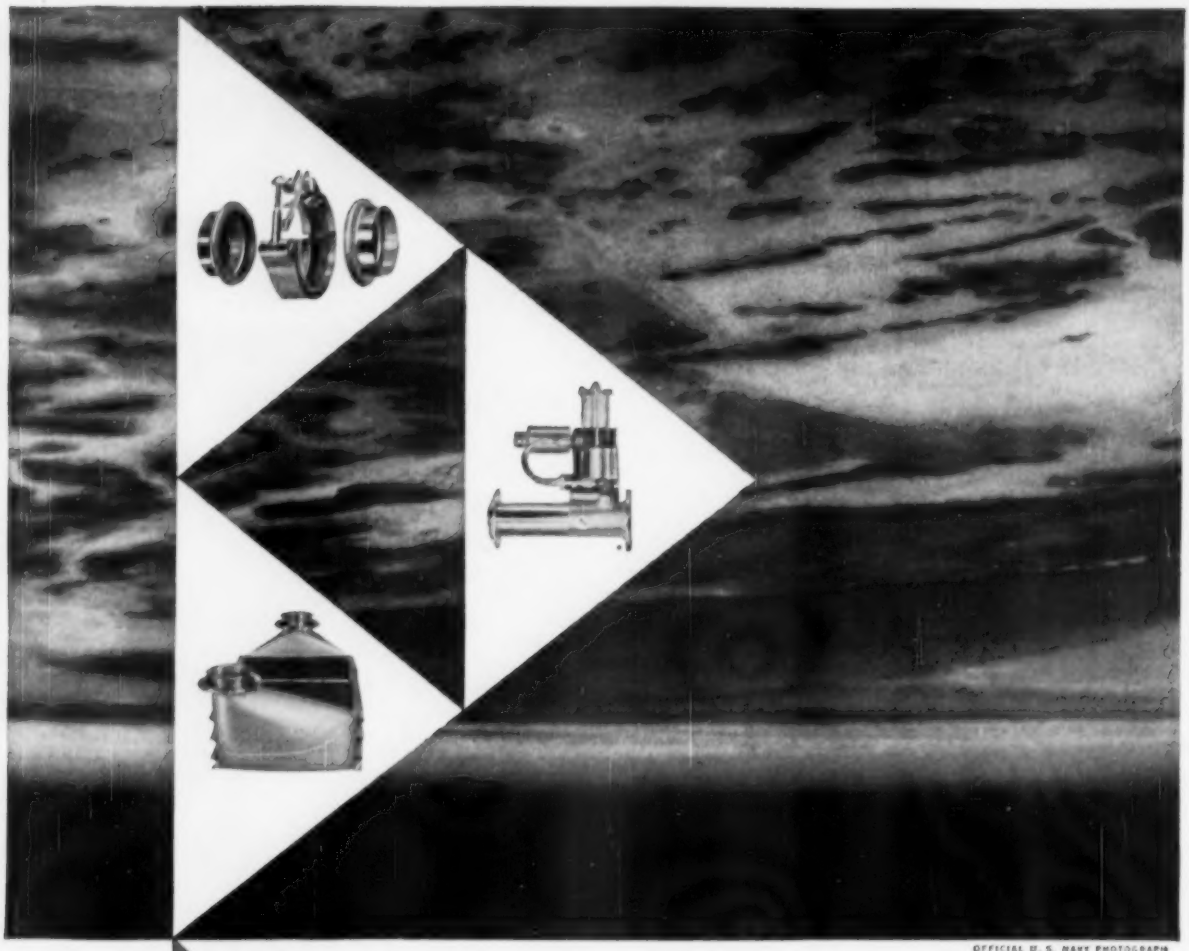

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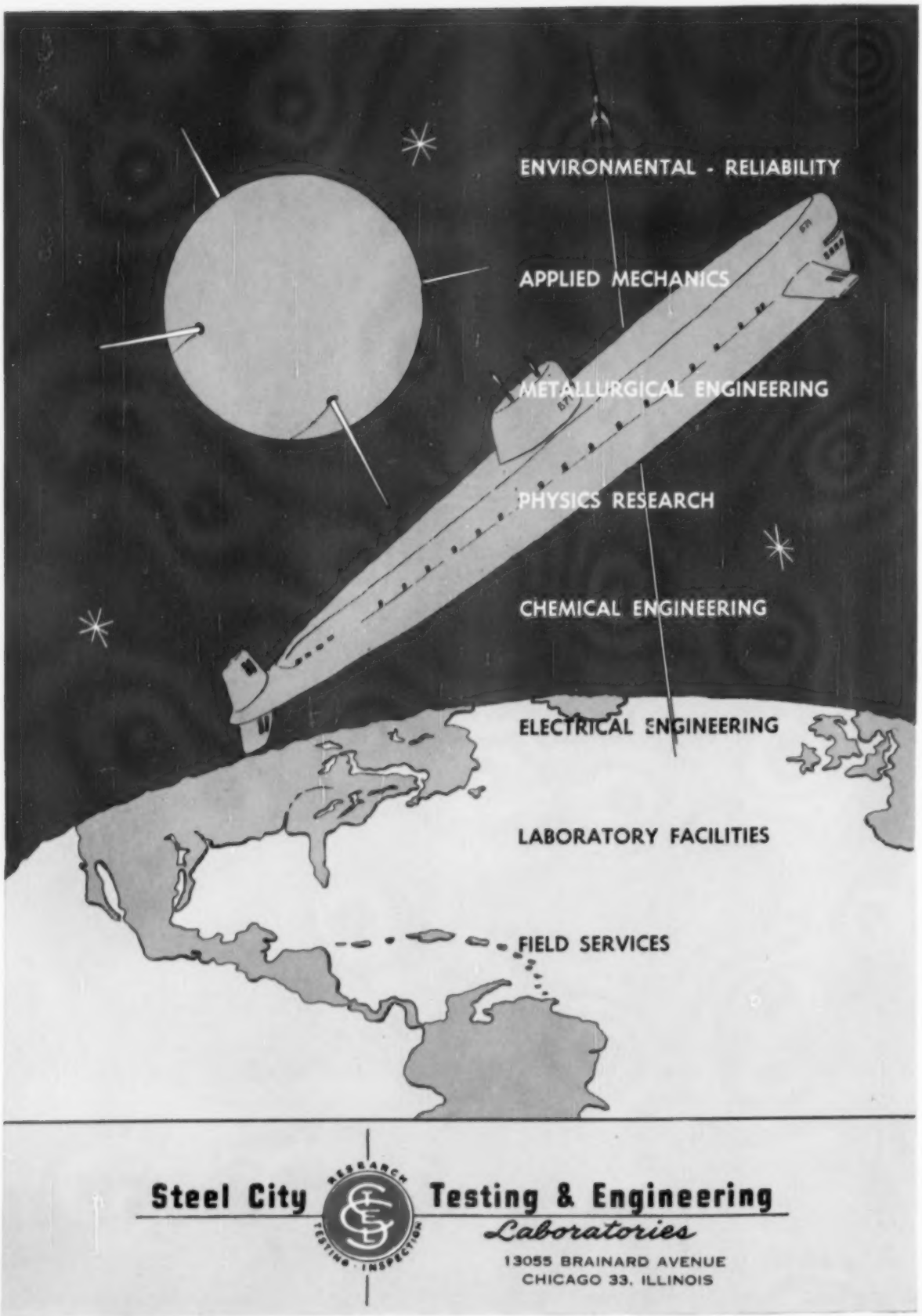
FOUR-STAGE rocket launching at NACA's Pilotless Aircraft Research Station, Wallops Island, Va.

Facilities



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Engine Test Facilities

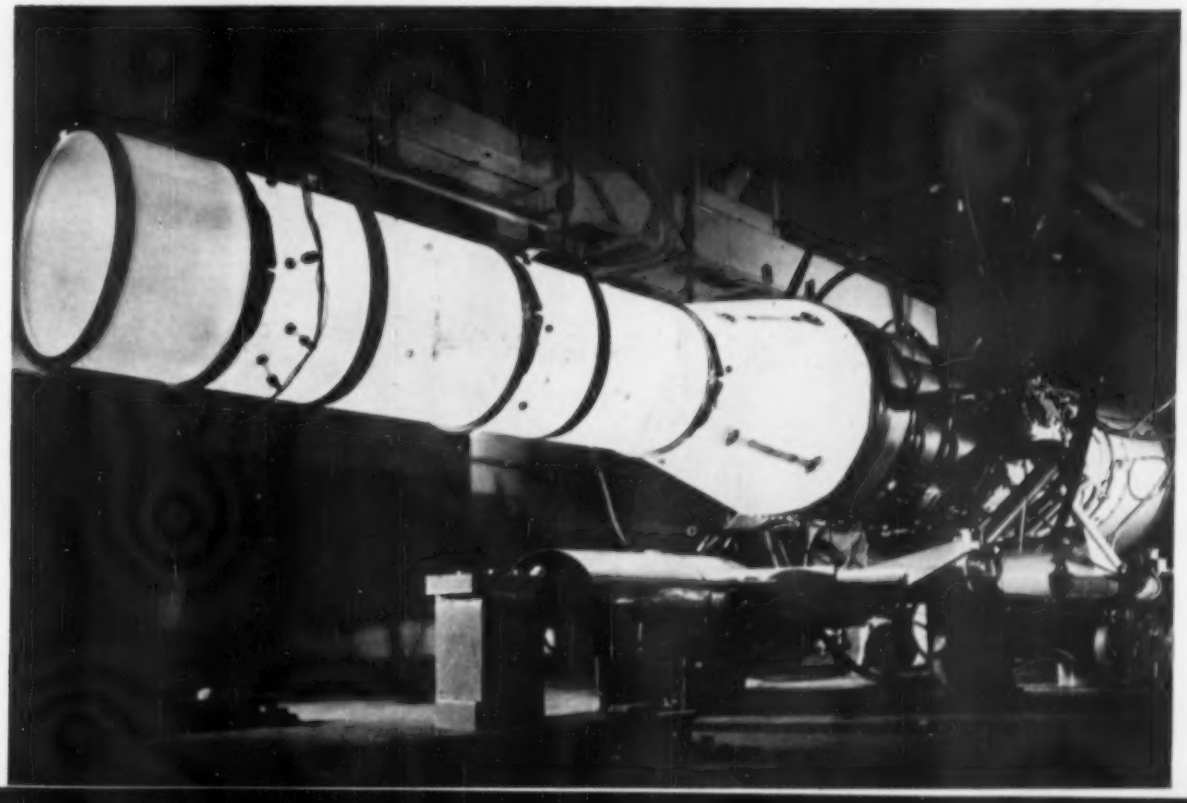
Facility Designation and Location	Primary Use	Test Chambers	Available to Others	Information Contact
NACA Propulsion Systems Laboratory Cleveland, Ohio	Turbojet, ramjet	Two	Limited basis	Director, NACA, 1512 H St. NW, Washington, D.C.
***GE Supersonic Propulsion Facility, Evendale, Ohio**	Development	Two	No	C. K. Soestmeyer
AEDC Ramjet Addition, Tullahoma, Tenn.	Turbojet, ramjet	Two	Yes	Cdr., ARDC, Box 1395, Balto., Md.
Andrew Wilgoos Lab., Pratt & Whitney, E. Hartford, Conn.	Turbojet, turboprop, ramjet	Seven		
Wright Aeronautical Division Ramjet Altitude Facility, Phase IV, Wood-Ridge, N. J.	Ramjet	Two	No	J. Kim, Mgr., Test Instr. & Equip. Div.
Marquardt Facility, Van Nuys, Calif.	Ramjet	Four	Limited basis	L. E. Dunn, Ch. Eng., Test Subdiv.
****Marquardt Facility, Weber Co., Utah**	Ramjet	Two	Limited basis	Same as above
AEDC Engine Test Facility, Tullahoma, Calif.	Turbojet, turboprop, ramjet	Four	Yes	Cdr., ARDC, Box 1395, Balto., Md.
NACA Altitude Wind Tunnel, Cleveland, Ohio	Turbojet, turboprop, ramjet	One	Limited basis	Director, NACA, 1512 H St. NW, Washington, D.C.
NACA Engine Research Building Altitude, Test Chambers SW-23, SW-24	Turbojet, ramjet	Two	Limited basis	Same as above
Allison Ram Cells, Plant #8, Maywood, Ind.	Turbojet	Two	No	T. W. Meeder, Aircraft Engine Operations, Allison Div., GMC
*****Allison Altitude Facility, Plant #8, Maywood, Ind.**	Turbojet	One	No	Same as above
Rosemont Research Laboratories, Turbojet & Combustion Res. Test Facility	Turbojet	Two	Yes	U. of Minn., Dept. of Aero. Eng., Rosemount Res. Labs.
NATTS Aeronautical Turbine Laboratories, Trenton, N.J.	Turbojet, turboprop	Five†	Priority to services	Cdr., NATTS
Ordnance Aerophysics Laboratory Daingerfield, Tex.	Ramjet, turbojet	Four	Yes	J. E. Arnold, Mgr., Daingerfield Div., Convair
Boeing Renton Facility, Renton, Washington	Airframe-engine compatibility, eng. perf. evaluating development	Two	No	B. F. Beekelman, Staff Eng., Power Plant, Pilotless Aircraft Div.

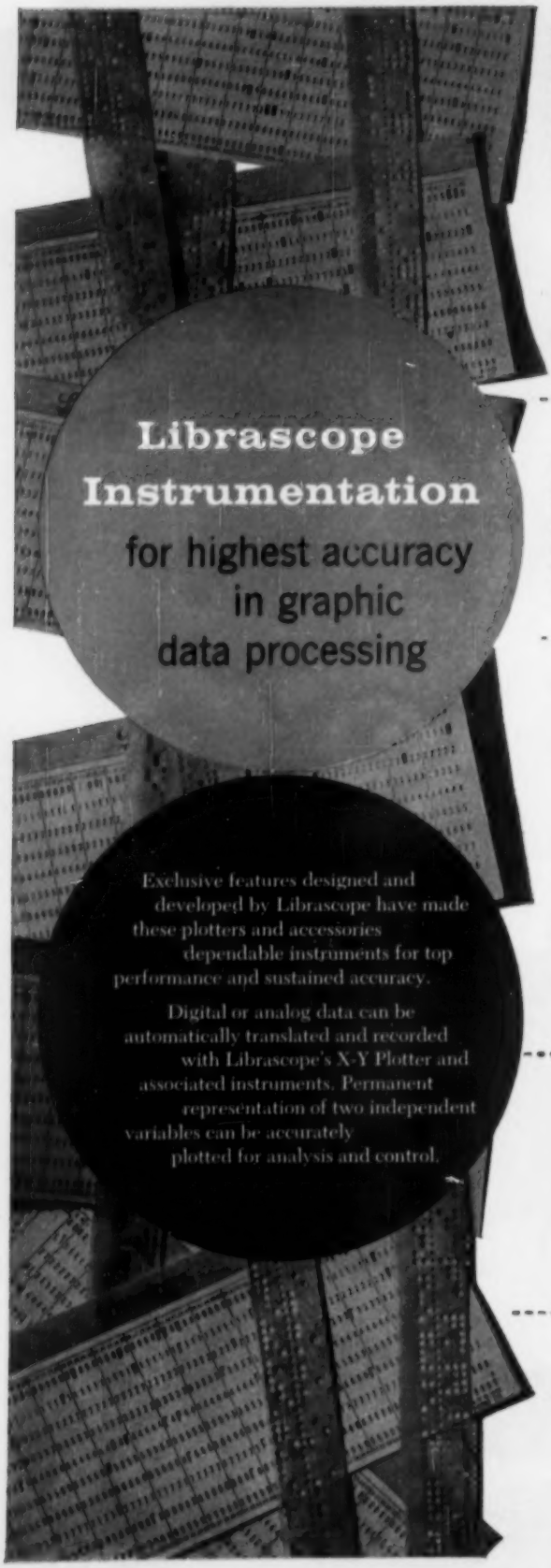
Abbreviations:

NACA—National Advisory Committee for Aeronautics
AEDC—Arnold Engineering Development Center (USAF)
NATTS—Naval Air Turbine Test Station

* 1958
** 1959
*** 1959
† (One under A&E contract)

MOLYBDENUM blades allow General Electric J47E engine to run at temperatures well above 1600F at Evendale, Ohio, facility.





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MODEL 200-A uses an input of 10,000 ohm resistance potentiometers as an input translator providing 10 to 1 scale expansion and origin positioning. Available standard digital input accessories are essentially inputs of this type. Any resistance potentiometer will provide an analog input for this configuration. Continuous or point plotting... Rack or case mounted.

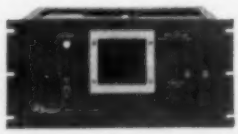
LIBRASCOPE XY DECIMAL KEYBOARD — This keyboard consists of a three-decimal bank for each axis with associated plus-minus keys. Depressing of the plotting bar initiates plot and clears keyboard automatically. Manual "clear" button is also provided. This unit features Librascope-developed positive-action non-sticking, self-wiping contacts.

LIBRASCOPE BINARY CONVERTER, MODEL 252 consists of two banks of relays and precision resistors simulating a precision potentiometer. The resistors weight the relays in straight binary so that each bank serves as an input to one axis of the XY plotter. Total resistance is 10,000 ohms per bank. Relays within the converter control the plot cycle.

Mounting: Standard RCA, RMA rack mounts.

LIBRASCOPE PUNCHED CARD CONVERTER — This relay-operated converter accepts three-decimal digit and sign, two channel, IBM punched card information and converts it to analog form for input to XY plotters. Cards can be manually fed through the IBM reading brushes one at a time or automatically read at rates to 50 cards per minute with an accuracy of 0.1%.

Mounting: Standard RCA or RMA rack mounts or in case.



LIBRASCOPE PUNCHED TAPE CONVERTER operates from punched tape reader. Can be modified to operate with any digital computers furnishing a punched tape output. If printed listing desired, unit may be operated from tape-actuated typewriter, such as the Flexowriter. Programming need not be specified on tape. Sequence operation. A particular tape may be programmed to accommodate various tape formats.

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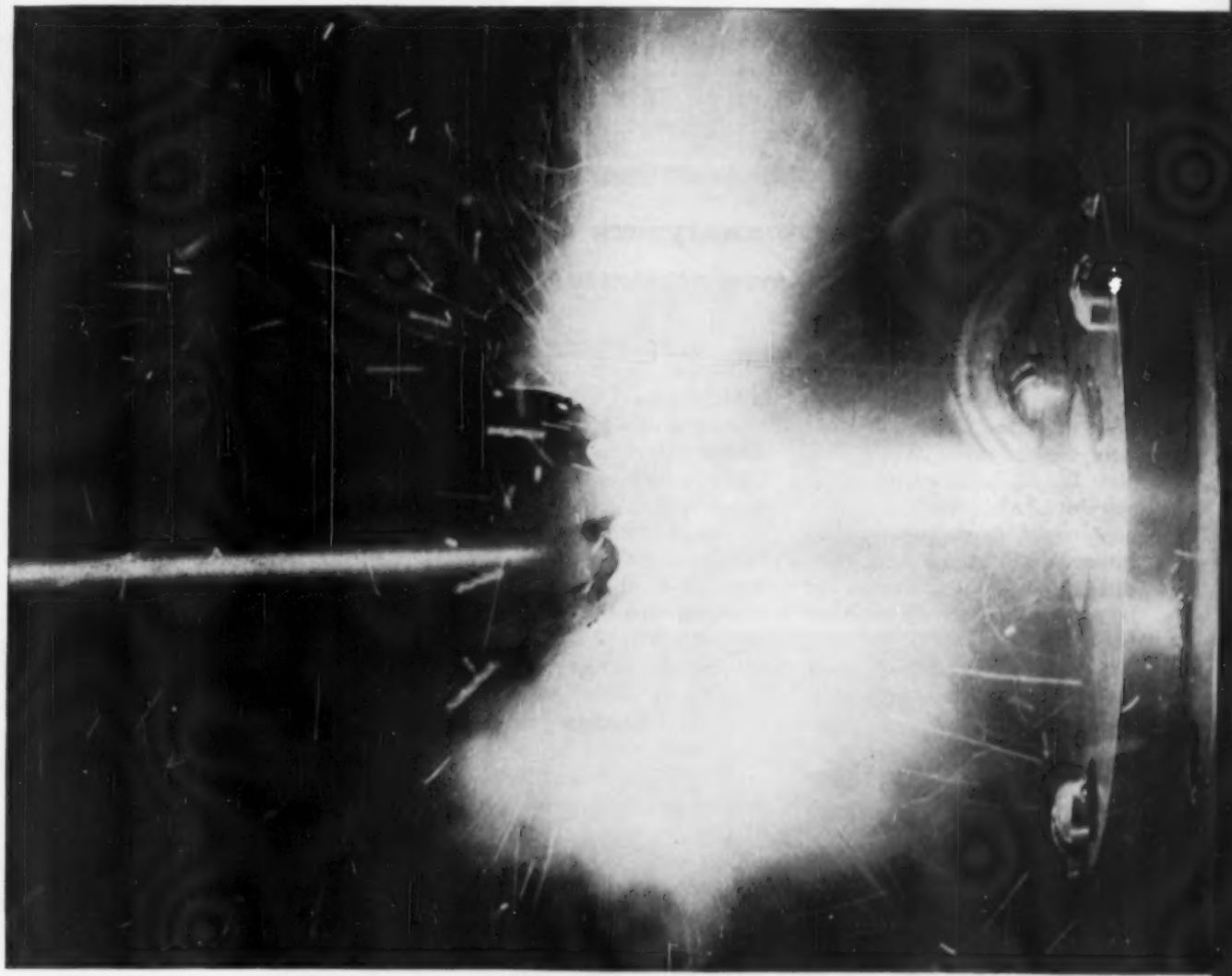
Large Hypersonic Wind Tunnels

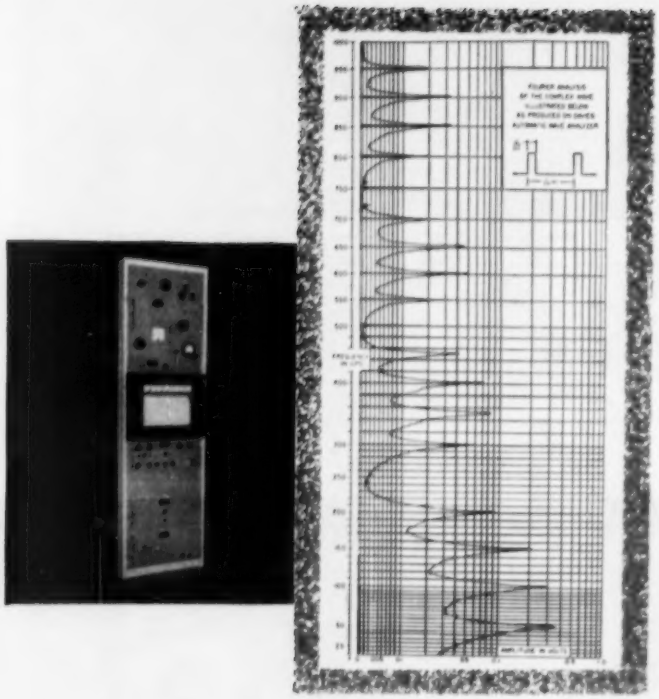
Tunnel Designation and Location	Test Section Dimensions	Mach Range	Pressurized; Flow	Available to Others	Information Contact
*AEDC Gas Dynamics Facility Tunnel B, Tullahoma, Tenn.	40" x 40"	4.5–10.0	Yes Continuous	Yes	Cdr., ARDC, Box 1395, Balto., Md.
** AEDC Tunnel F, Tullahoma, Tenn.	48" x 48"	8.0–20.0	Yes Intermittent	Yes	Same as above

Abbreviations:
AEDC—Arnold Engineering Development Center,

* 1959
** 1960



PLASMA JET, newer type of research tool, pours 10,000K stream on blunt shape at Giannini Research Laboratory.



Once the data is on magnetic tape, there still remains the job of analyzing it. You can convert it to digital values, manually measure and sample it, and feed it to a digital computer on punched cards . . . but that takes considerable time and effort by skilled personnel. Rather than limit the number of analyses taken and the length of samples analyzed, labs are turning to direct analog analysis, which merits consideration by speeding reduction . . . permitting larger samples . . . increasing statistical reliability.

how automatic wave analyzers speed analog data reduction, improve statistical reliability

Automatic wave analysis is probably the least complicated technique for reducing analog data. Feed the taped data to an analyzer, flip the switch, and a complete Fouriér series is automatically plotted and printed in permanent record form. There are no intermediate steps, and what little the operator has to do can be trusted to relatively unskilled personnel.

Both of the two models available from Davies can accurately plot Fouriér series data as either *amplitude* versus *frequency* or *power* versus *frequency* at the flip of a selector switch. Both are also equipped with a "quick look" facility. Model 9020A provides a quick analysis across its frequency range of 3 cps. to 2 kc in 6 minutes; Model 9050A across its range of 3 cps. to 10 kc in just 15 minutes. Linear or square law output, as desired, is recorded by a Brown *ElectroniK* Potentiometer as a large, easily readable plot. You can visualize results immediately without any further curve tracing.

Multichannel inputs permit you to analyze as many as seven channels of data simultaneously. But the ultimate in automation is provided by the addition of a Davies Automatic Channel Selector, which you can program for serial analysis of up to 14 channels, changing tape speed, bandwidth, and output as you desire . . . all without any further attention.

It must be conceded that, while Davies Analyzers do provide high amplitude accuracy across wide frequency ranges, no analog analysis equipment could provide the *point* accuracy of manual and digital computer methods. But too often, that point accuracy is only achieved at the expense of reliable results. The speed with which Davies Automatic Wave Analyzers can run through data—in as little as 3% of the time required by digital methods—permits such large samples to be analyzed that the statistical reliability of the overall result remains unequalled.

That's why Davies Analyzers, first designed for aircraft studies, have since been successfully applied to vibration, noise, shock, and flutter analysis in vehicles, aircraft, missiles, and ships . . . seismic interpretation . . . power-line disturbance analysis . . . noise analysis . . . and any number of other phenomena characterized by randomly fluctuating data.

You'll find considerable additional information on Davies Automatic Wave Analyzers, how they operate, and what you can expect from them in the way of specific performance characteristics in Bulletin 9001. Write Minneapolis-Honeywell Regulator Co., Davies Laboratories Division, 10721 Hanna Street, Beltsville, Maryland, or call Webster 5-2700.

MINNEAPOLIS **Honeywell**

DAVIES LABORATORIES DIVISION

Circle Number 118 on Reader-Service Card

Small Hypersonic Wind Tunnels

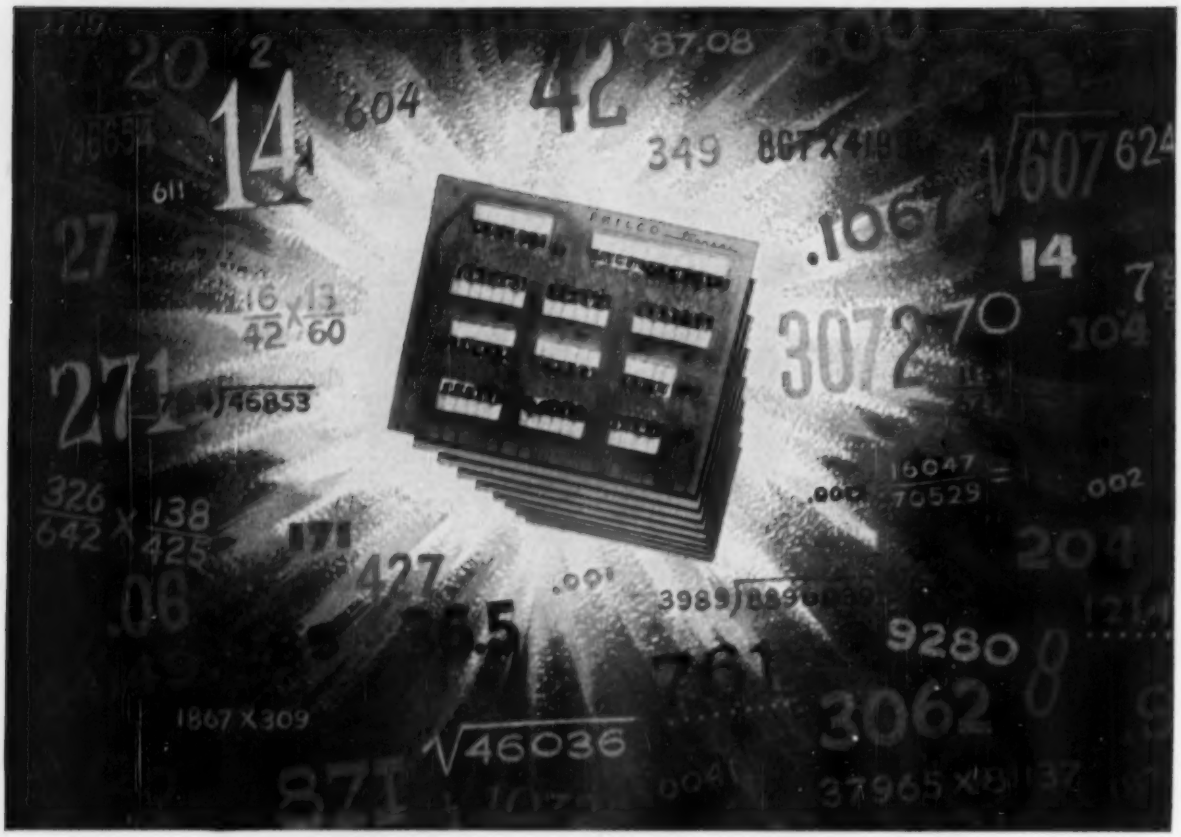
Tunnel Designation and Location	Test Section Dimensions	Mach Range	Pressurized; Flow	Available to Others	Information Contact
Aberdeen Proving Ground, Md., #4	15" x 15"	5.0–10.0	Variable; Continuous	All services	Dir., Ballistics Res. Laboratory
*Naval Ordnance Laboratory Tunnel #8 Silver Spring, Md.	20" x 18"	5.0—10.0	Yes Blowdown	Yes	Cdr., NOL, White Oak, Silver Spring, Md.
AEDC Gas Dynamics Facility Tunnel E-2, Tullahoma, Tenn.	12" x 12"	4.5–10.0	Yes Intermittent	Yes	Cdr., ARDC, Box 1395, Balto, Md.
NACA 10" Hypersonic Tunnel, Moffett Field, Calif.	12" x 10"	2.8–6.0	Yes Continuous	Yes	Director, NACA, 1512 H St. NW, Washington, D.C.
**NACA Supersonic Free-Flight Tunnel, Moffett Field, Calif.	12" x 24"	2.0–11.0	Yes Intermittent	Yes	Same as above
NACA 10" x 14", Moffett Field, Calif.	10" x 14"	2.7–6.3	Yes Continuous	Yes	Same as above
NACA 11" Hypersonic Tunnel, Langley Field, Va.	11" x 11"	6.8–10.0	Yes Intermittent	Yes	Same as above
***Jet Propulsion Laboratory 21" Hypersonic Tunnel, Pasadena, Calif.	21" x 21"	5.0–8.5	Yes Continuous	Services; Priority to USA, USAF	Dir., JPL, Calif. Inst. of Technology
Ohio State University, #3, Columbus, Ohio	9"	8.0–14.0	Yes Continuous	Limited basis	Dept. of Aeronautical Engineering
Brooklyn Polytechnic Institute Hypersonic Tunnel Leg #1, Freeport, N.Y.	12" diam. 14" diam.	6.0–8.0	Yes Continuous	Yes	Dr. A. Ferri, Dir., Aerodynamics Lab., Polytechnic Inst. of Brooklyn
Rosemount Research Laboratories 12" x 12" Hypersonic Tunnel, Minneapolis, Minn.	12" x 12"	2.0–10.0	Yes (to 40 atmos.) Intermittent	Yes	U. of Minn., Dept. of Aero. Eng., Rosemount Res. Labs.

Abbreviations:
AEDC—Arnold Engineering Development Center
NACA—National Advisory Committee for Aeronautics

* 1959
** Gun-launched model
*** 1958

MODEL fired in light-gas gun at NACA's Ames Laboratory, top, travels 10,000 mph., generates own light.

MATHEMAGICS!



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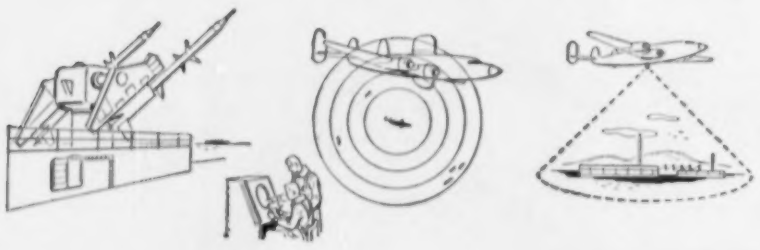

Out of Philco laboratories come far reaching developments in vital military electronic equipment to make a stronger U.S.A. on land, sea and in the air. Philco is proud to be working with the Armed Forces in all parts of the globe with a worldwide service organization of trained specialists.

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Circle Number 112 on Reader-Service Card

Large Transonic Wind Tunnels

Tunnel Designation and Location	Test Section Dimensions	Mach Range	Pressurized; Flow	Available to Others	Information Contact
David Taylor Model Basin 7' x 10' Transonic, Carderock, Md.	7' x 10'	0.2–1.2	Yes Continuous	Yes	Director, DTMB, Attn: Aerodynamics Officer
AEDC Propulsion Wind Tunnel Supersonic, Leg, Tullahoma, Tenn.	16' x 16'	0.8–1.6	Yes Continuous	Yes	Cdr., ARDC, Box 1395, Balto., Md.
WADC 10' Transonic, Wright-Patterson AFB, Ohio	10' diam.	0–1.24	Yes Continuous	Yes	Same as above
NACA 8' x 6' Supersonic, Cleveland, Ohio	8' x 6'	0.6–2.1	No Continuous	Yes	Director, NACA, 1512 H St. NW, Washington, D. C.
NACA 8' Transonic, Langley Field, Va.	7.3' dodecagon	0.6–1.2	No Continuous	Yes	Same as above
NACA 8' Transonic, Langley Field, Va.	7.1' x 7.1'	0.6–1.4	Yes Continuous	Yes	Same as above
NACA 16' Transonic, Langley Field, Va.	15.5' x 15.5'	0.2–1.1	No Continuous	Yes	Same as above
*NACA 19', Langley Field, Va.	16' x 16'	0–1.15	Yes Continuous	Yes	Same as above
NACA Ames Unitary, Moffett Field, Calif.	11' x 11'	0.75–1.5	Yes Cutinuous	Yes	Same as above
NACA 14' Transonic, Moffett Field, Calif.	13.5' x 13.5'	0.6–1.2	No Continuous	Yes	Same as above
NACA 6' x 6', Moffett Field, Calif.	6' x 6'	0.6–2.4	Yes Continuous	Yes	Same as above
**NACA High-speed 7' x 10', Langley Field, Va.	7' x 10'	0.4–1.2	No Continuous	Yes	Same as above
Boeing Transonic, Seattle, Wash.	8' x 12'	0–1.2	No Continuous	No	J. H. Russell, Ch., Wind Tunnel Eng.
***Chance Vought High-speed 4', Dallas, Tex.	4' x 4'	0.5–4.2†	Yes Intermittent	No	R. F. Bingham Spvsr., Wind Tunnel Operations
Convair 4' x 4', San Diego, Calif.	4' x 4'	subsonic–5.0	Yes Intermittent	Limited basis	W. T. McCarthy, Mgr., Wind Tunnel
Cornell Aeronautical Laboratory 8' TR, Buffalo, N. Y.	8' x 8'	0–1.3	Yes Continuous	Yes	R. S. Kelm, Head, Wind Tunnel Dept., Cornell Aero. Lab., 4455 Genesee St., Buffalo 21
Douglas 6' x 6' Blowdown, El Segundo, Calif.	6' x 6'	0.2–5.0	Yes Intermittent (40 sec.)	No.	E. H. Heinemann, Chief Eng., El Segundo Div.
Martin Transonic Circuit, Middle River, Md.	3' x 3'	0–1.2	Yes Continuous	No	L. G. Cooper, Glenn L. Martin Co.
So. Cal. Cooperative Wind Tunnel, Pasadena, Calif.	7.5' x 9.75'	0–1.3	Yes Continuous	Yes	P. F. Keller, Chief, Operations, 950 S. Raymond Ave.
North American Trisonic, Los Angeles, Calif.	7' x 7'	0.2–3.5	Yes Intermittent	No	

Abbreviations:
AEDC—Arnold Engineering Development Center,
WADC—Wright Air Development Center (USAF)
NACA—National Advisory Committee for Aeronautics

*1950
**1950
***1958
†By addition of heater, 5.0

HELICOPTER rotor blades are tested in 40 by 80 ft. wind tunnel at Ames Laboratory.

From imagination in research,

from creative engineering in design and development,

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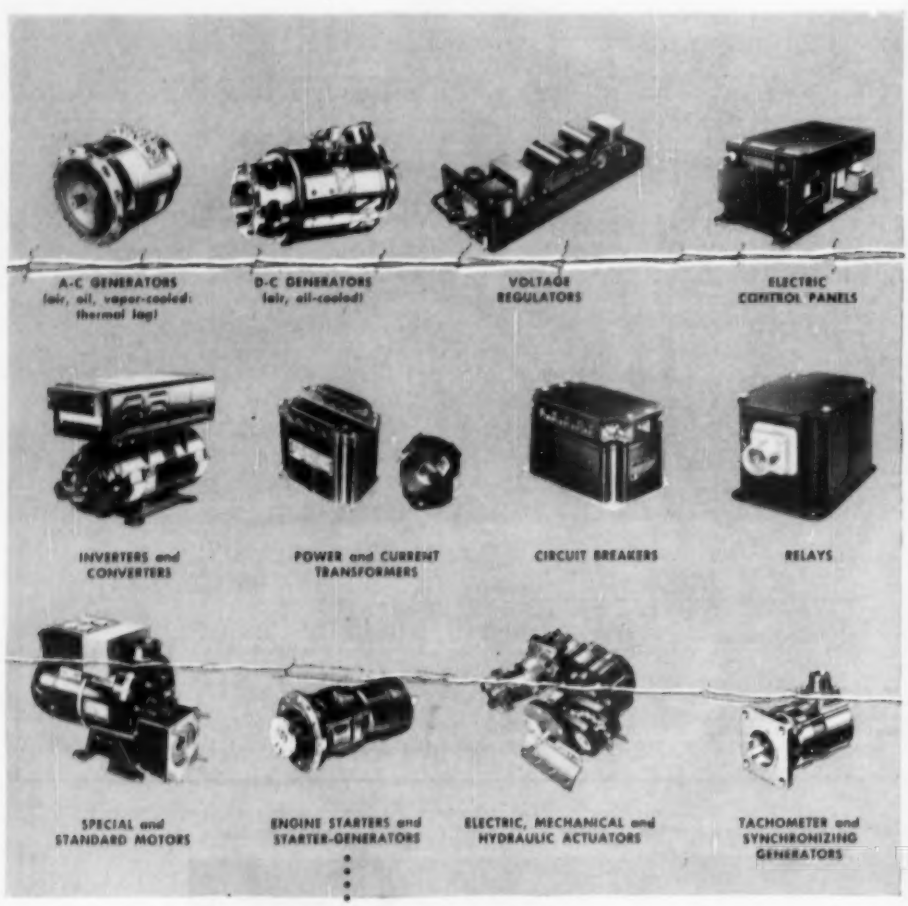

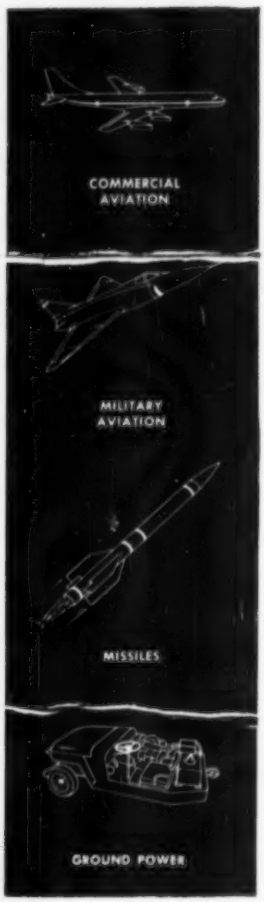

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Small Transonic Wind Tunnels

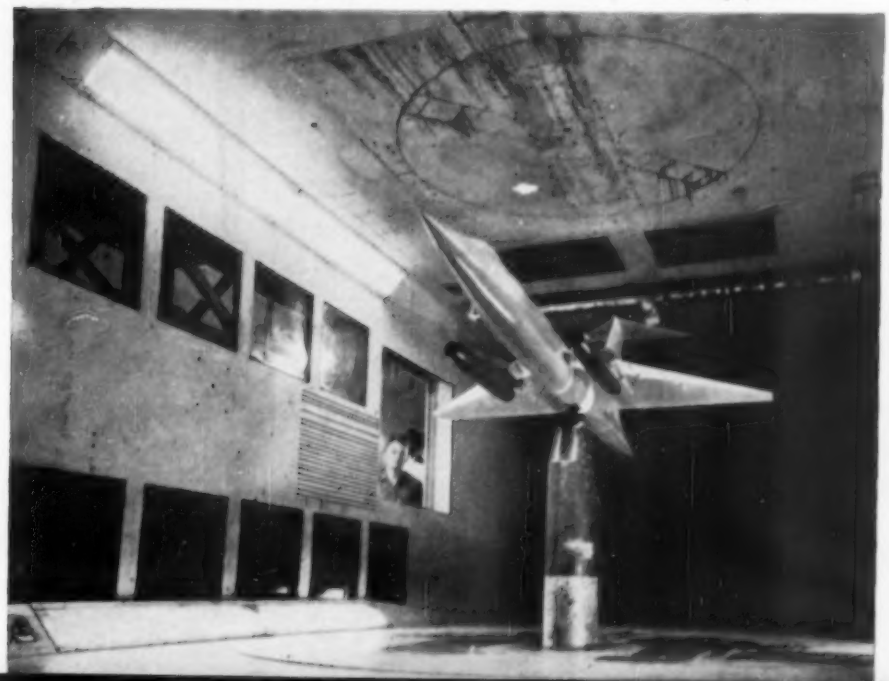
Tunnel Designation and Location	Test Section Dimensions	Mach Range	Pressurized: Flow	Available to Others	Information Contact
Army Ballistic Missile Agency 14", Redstone Arsenal	14" x 14"	0.5–5.5	Yes Intermittent	Limited basis	T. G. Reed, Redstone Arsenal
NAMTC Aerodynamic Test Div., Pt. Mugu, Calif.	16" x 16"	0–1.6	Yes Continuous	Yes	Cdr.; NAMTC, Attn: Aero. Test Div.
David Taylor Model Basin Carderock, Md.	18" x 18"	0–1.2	No Intermittent	Yes	Director, DTMB, Attn: Aerodynamics Officer
David Taylor Model Basin, Carderock, Md.	9.5" x 9.5"	0–1.2	No Intermittent	Yes	Same as above
AEDC 12" transonic, Tullahoma, Tenn.	12" x 12"	0.8–1.6	Yes Continuous	Yes	Cdr., ARDC, Box 1395 Balto, Md.
NACA Flutter, Langley Field, Va.	2' x 4'	0–1.2	Yes Continuous	Yes	Director, NACA, 1512 H St. NW, Washington, D.C.
NACA 9' x 12' Supersonic, Langley Field, Va.	9" x 12"	0.7–1.9	Yes Intermittent	Yes	Same as above
NACA 26" Transonic, Langley Field, Va.	26" octagon	0.7–1.4	Yes Intermittent	Yes	Same as above
NACA 2' x 2', Moffett Field, Calif.	24" x 24"	0–1.4	Yes Continuous	Yes	Same as above
NACA 1' x 3.5', Moffett Field, Calif.	12" x 35"	0.3–1.05	No Continuous	Yes	Same as above
Brown Univ. Transonic-Supersonic, Providence, R.I.	9" x 9"	0.25–2.0	No Continuous	Occupancy rate basis	Dr. P. F. Maeder, Aero. Res. Lab., Div. of Eng.
General Electric North Cascade Small Transonic, Evendale, Ohio	6" x 18"	0–TR	Yes Continuous	No	E. E. Stoeckly
Massachusetts Institute of Technology Transonic, Blowdown	22" octagon	0.5–1.3	Yes Intermittent	Partial	J. Bicknell
North American 16" Supersonic, Los Angeles, Calif.	15.75" x 15.75"	0.4–3.75	No Intermittent	No	
Ohio State University No. 1, Columbus, Ohio	12" x 12"	0.6–3.0	Yes Intermittent	Limited basis	Ohio St. Univ., Columbus, Ohio
Rosemount Research Laboratories 12" x 16", Minneapolis, Minn.	12" x 16"	0–1.3	No Continuous	Yes	U. of Minn., Dept. of Aero. Eng., Rosemount Res. Labs.
United Aircraft 17" x 17" Transonic, E. Hartford, Conn.	17" x 17"	0.6–1.5	Yes (5 atmos.) Intermittent	Limited basis	J. G. Lee, Dir of Res., UAC

Abbreviations:

NAMTC—Naval Air Missile Test Center

AEDC—Arnold Engineering Development Center (USAF)
NACA—National Advisory Committee for Aeronautics

SUBSONIC stability of high-speed model is studied in 7 by 10 ft. Langley tunnel.



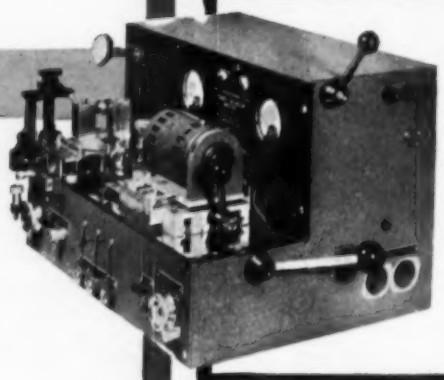
Locates Measures Corrects

DYNAMIC UNBALANCE

of miniature high speed gyro rotors

Detailed information is in Instrument Data Sheet 211, available upon request to Technical Literature Section.

decker **DYNAMIC BALANCER**



without removing the rotor from the mount

Even miniature missile type gyro rotors can be balanced in 6 to 10 minutes with the DECKER DYNAMIC BALANCER. And ultimate balance is generally limited only by the quality of the rotor bearings.

Designed specifically for high speed rotors requiring maximum possible precision of balance, the Model 211 Dynamic Balancer is capable of handling any rotor which may be electrically driven at 10,500 rpm or higher.

The Balancer offers, on a single portable chassis, everything needed for precision dynamic balancing. Included are the necessary equipment for rotor mounting, measurement, and location of unbalance, plus a precise metered automatic drill for unbalance correction.

- Maintains laboratory type precision balance on a production basis
- Does not require a skilled technician
- Automatic marking of point of unbalance
- Drilling performed without removing rotor.
- Precise indication of degree of unbalance
- Automatic speed control
- Rapid run up to proper speed
- Completely self contained and portable (11" x 15" x 21")
- Rapid work change over

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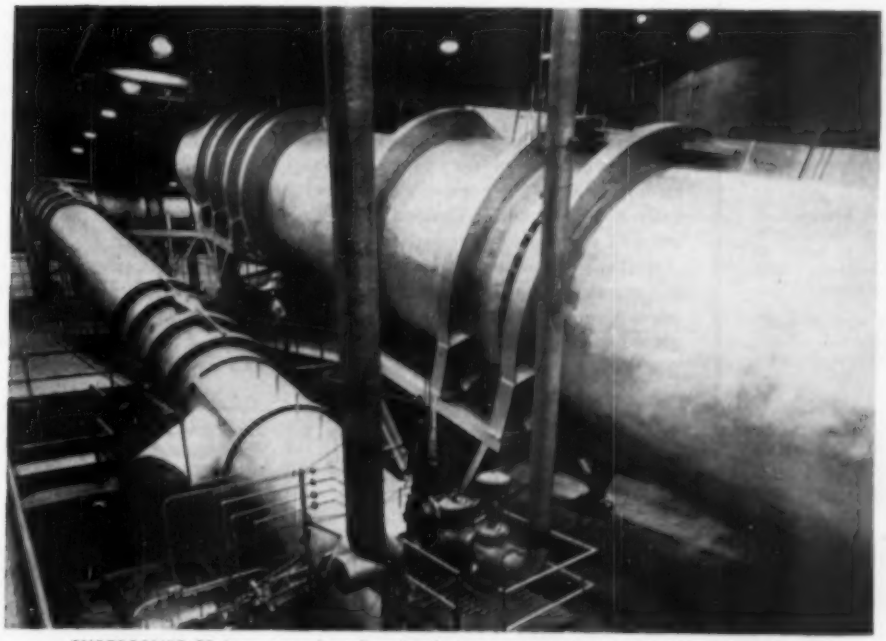
Circle Number 114 on Reader-Service Card

Large Supersonic Wind Tunnels

Tunnel Designation and Location	Test Section Dimensions	Mach Range	Pressurized; Flow	Available to Others	Information Contact
AEDC Gas Dynamics Facility Tunnle A, Tullahoma, Tenn.	40" x 40"	1.2–5.5	Yes Continuous	Yes	Cdr., ARDC, Box 1395, Balto., Md.
*AEDC Supersonic Propulsion Wind Tunnel, Tullahoma, Tenn.	16' x 16'	1.4–4.9	Yes Continuous	Yes	Same as above
NACA 8' x 8' Supersonic Wind Tunnel, Cleveland, Ohio	3' x 6'	0.6–2.1	No Continuous	Yes	Director, NACA, 1512 H ST., NW, Washington, D.C.
NACA Ames Unitary, Moffett Field, Calif.	9' x 7' 8' x 7'	1.4–2.6 2.4–3.5	Yes Continuous	Yes	Same as above
NACA 6' x 6', Moffett Field, Calif.	6' x 6'	0.6–2.4	Yes Continuous	Yes	Same as above
NACA Lewis Unitary, Cleveland, Ohio	10' x 10'	2.0–3.5	Yes Continuous	Yes	Same as above
NACA 4' x 4' Supersonic Propulsion Wind Tunnel, Langley Field, Va.	4.5' x 4.5'	1.25–2.2	Yes Continuous	Yes	Same as above
NACA Langley Unitary, Langley Field, Va.	4' x 4' 4' x 4'	1.5–2.8 2.5–5.0	Yes Continuous	Yes	Same as above
NACA 6' x 6' Structures Tunnel, Langley Field, Va.	6' x 8.75'	1.5–3.0	Yes Intermittent	Yes	Same as above
Boeing Supersonic, Seattle, Wash.	4' x 4'	1.2–4.0	Yes Intermittent	No	J. H. Russell, Ch. Wind Tunnel Eng.
Convair 4' x 4', San Diego, Calif.	4' x 4'	Subsonic-5.0	Yes Intermittent	Limited basis	W. T. McCarthy, Mgr., Wind Tunnes
So. Cal. Cooperative Wind Tunnel, Pasadena, Calif.	8.5' x 11.25'	0–0.95 1.1–1.8	Yes Continuous	Yes	P. F. Keller, Ch., Operations, 950 S. Raymond Ave.
North American Trisonic, Los Angeles, Calif.	7' x 7'	0.2–3.5	Yes Intermittent	No	
**Chance Vought High-speed 4', Dallas, Tex.	4' x 4'	0.5–4.2†	Yes Intermittent	No	R. F. Ringham, Spvsr., Wind Tunnel Operations
***Douglas 6' x 6' Blowdown, El Segundo, Calif.	6' x 6'	0.2–5.0	Yes Intermittent (40 sec.)	No	E. H. Heinemann, Chief Eng., El Segundo, Div.

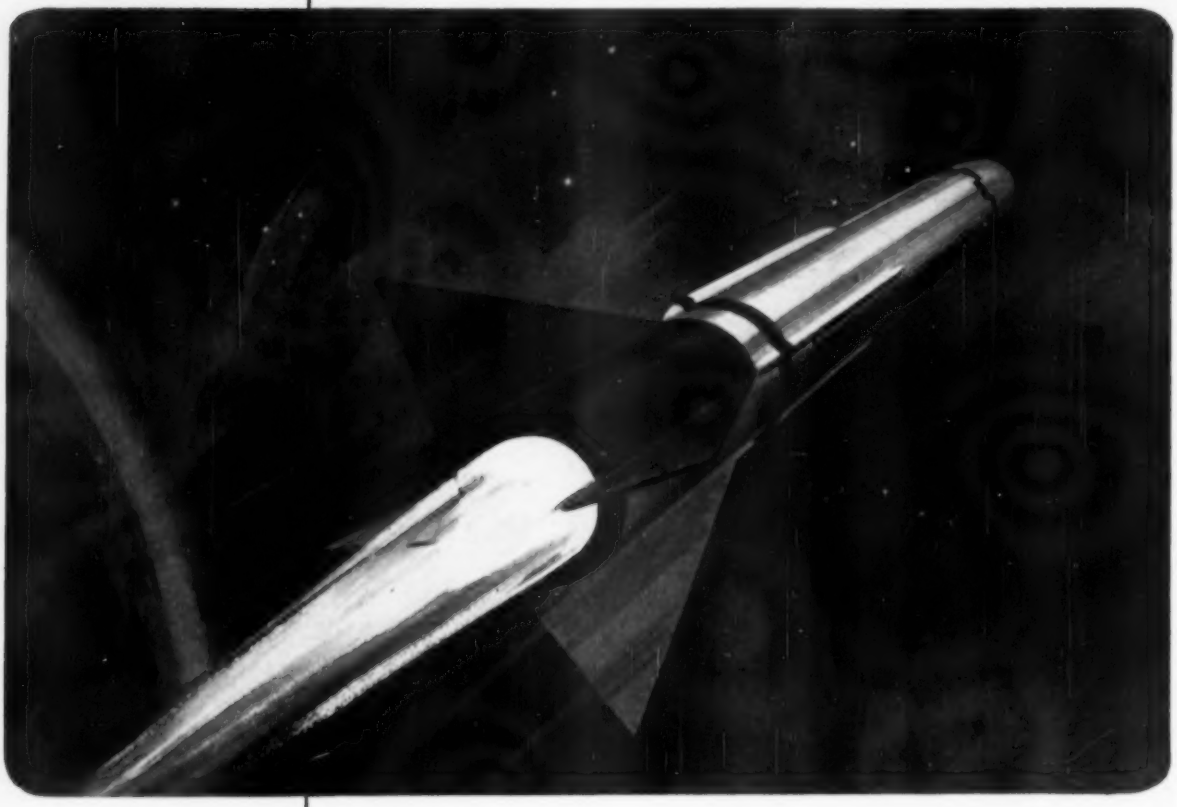
Abbreviations:
AEDC—Arnold Engineering Development Center,
NACA—National Advisory Committee for Aeronautics

*1959
**1956
***1952
†By addition of heater, 5.0



SUPERSONIC Unitary tunnel at Langley Laboratory requires 2,700 tons of ducting.

IMPORTANT DEVELOPMENTS AT JPL



Weapons Systems Responsibility

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In the development of guided missile systems, the Jet Propulsion Laboratory maintains a complete and broad responsibility. From the earliest conception to production engineering—from research and development in electronics, guidance, aerodynamics, structures and propulsion, through field testing problems and actual troop use, full technical responsibility rests with JPL engineers and scientists.

The Laboratory is not only responsible for the missile system itself, including guidance, propulsion and airframe, but for all ground handling equipment necessary to insure a complete tactical weapons system.

One outstanding product of this type of systems responsibility is the "Corporal," a highly accurate surface-to-surface ballistic missile. This weapon, developed by JPL, and now in production elsewhere, can be found "on active service" wherever needed in the American defense pattern.

A prime attraction for scientists and engineers at JPL is the exceptional opportunity provided for original research afforded by close integration with vital and forward-looking programs. The Laboratory now has important positions open for qualified applicants for such interesting and challenging activities.

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A DIVISION OF CALIFORNIA INSTITUTE OF TECHNOLOGY

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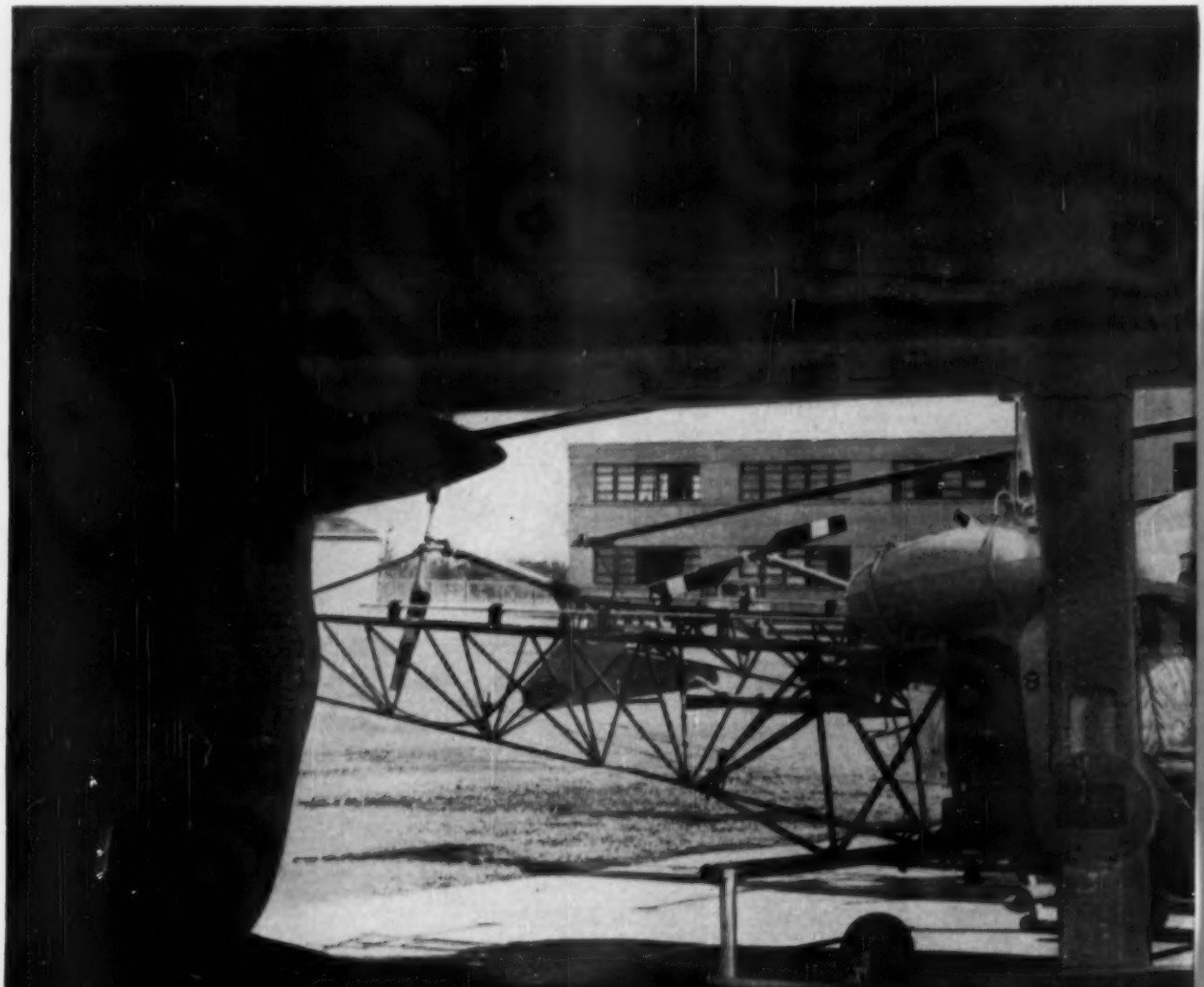
Small Supersonic Wind Tunnels

Tunnel Designation and Location	Test Section Dimensions	Mach Range	Pressurized; Flow	Available to Others	Information Contact
Aberdeen Proving Ground, Md., #1	13" x 13" x 30"	1.3–5.0	Variable; Continuous	Yes	Dir. Ballistics Res. Laboratory
Aberdeen Proving Ground, Md., #3	20" x 18" x 36"	1.25–4.9	Variable; Continuous	Yes	Same as above
NAMTC Aerodynamic Test Div., Pt. Mugu, Calif.	20.8" x 17"	1.6–3.5	Yes Continuous	Yes	Cdr; NAMTC, Attn: Aero. Test Div.
Naval Supersonic Lab., MIT, Cambridge, Mass.	18" x 18" 24" x 18"	1.5–4.0	Yes Continuous	Partial	J. R. Markham
DTMB, Carderock, Md	18" x 18"	1.2–2.92	No; Intermittent	Yes	Director, DTMB; Aerodynamics Officer
DTMB, Carderock, Md.	9.5" x 9.5"	1.2–2.92	No; Intermittent	Yes	Same as above
NOL Tunnel #1, Silver Springs, Md.	16" x 16"	1.2–5.0	No; Intermittent	Yes	Cdr.; NOL, Silver Spring, Md.
NOL Tunnel #2	16" x 16"	1.2–5.0	Yes; Continuous	Yes	Same as above
OAL, Daingerfield, Tex.	27.5" x 19"	1.25–2.50	Yes Continuous	Yes	J. E. Arnold, Mgr., Daingerfield Div., Convair
WADC 2' SS, Wright-Patterson AFB, Ohio	24" x 24"	1.5–2.3	Yes, Continuous	Yes	Cdr., ARDC, Box 1395, Balto., Md.
AEDC GDF Tunnel E-1, Tullahoma, Tenn.	12" x 12"	1.2–5.5	Yes; Intermittent	Yes	Same as above
AEDC GDF Tunnel D, Tullahoma, Tenn.	20" x 20"	1.4–5.0	Yes; Intermittent	Yes	Same as above
AEDC 12" SS, Tullahoma, Tenn.	12" x 12"	1.4–4.9	Yes; Continuous	Yes	Same as above
NACA 9" x 18" Blowdown, Langley Field, Va.	9" x 18"	0–4.0	Yes; Intermittent	Yes	Director, NACA, 1512 H St. N.W., Washington, D. C.
NACA Blowdown Jet	12" x 12"; 27" x 27"	0–3.0	No; Intermittent	Yes	Same as above
NACA 9" x 12" SS, Langley Field, Va.	9" x 12"	0.7–1.9	Yes; Intermittent	Yes	Same as above
NACA 9" SS, Langley Field, Va.	9" x 9"	1.5–3.3	Yes; Continuous	Yes	Same as above
*NACA Variable Mach Blowdown, Langley Field, Va.	20" x 20"	1.6–6.0	Yes Intermittent	Yes	Same as above
NACA 10" HT, Moffett Field, Calif.	12" x 10"	2.8–6.0	Yes; Continuous	Yes	Same as above
**NACA SSFFT, Moffett Field, Calif.	12" x 24"	2.0–11.0	Yes; Intermittent	Yes	Same as above
NACA 10" x 14", Moffett Field, Calif.	10" x 14"	2.7–6.3	Yes; Continuous	Yes	Same as above
NACA 1' x 3' #1, Moffett Field, Calif.	12" x 36"	1.2–4.2	Yes; Continuous	Yes	Same as above
NACA 1' x 4' #2 Blowdown, Moffett Field, Calif.	12" x 36"	1.2–3.8	Yes Intermittent	Yes	Same as above
NACA 1' x 1' SS, Cleveland, Ohio	12" x 12"	3.12	Yes; Continuous	Yes	Same as above
NACA 18" x 18", Cleveland, Ohio	18" x 18"	1.91	Yes; Continuous	Yes	Same as above
NACA 18" x 18", Cleveland, Ohio	18" x 18"	3.05	Yes; Continuous	Yes	Same as above
NACA 24" x 24", Cleveland, Ohio	24" x 24"	3.96	Yes; Continuous	Yes	Same as above
Boeing #1, Renton, Washington	12" x 17"	2.0 only	Yes Intermittent	Not at present	B. F. Beckelman, Staff Eng., Power Plant, Pilotless Aircraft Div.
Boeing #2, Renton, Washington	12" x 17"	2.5	Yes; Intermittent	Same	Same as above
Grumman 12" SS, Freeport, N. Y.	12" x 12"	1.4–4.0	No Intermittent	No	W. Gander, Wind Tunnel Project Eng., Grumman Aircraft Engineering Corp.
Brown U. TR-SS, Providence, R. I.	9" x 9"	0.25–2.0	No Continuous	Occupancy rate basis	Dr. P. F. Maeder, Aero. Res. Lab., Div. of Eng.
JPL 12" SS, Pasadena, Calif.	12" x 12"	1.4–4.0	Yes Continuous	Services; Priority to USA, USAF	Dir., JPL, Calif. Inst. of Technology
JPL 20" SS, Pasadena, Calif.	18" x 20"	1.3–5.0	Yes Continuous	Service; Priority to USA, USAF	Same as above
Marquardt Cell #5, Van Nuys, Calif.	10" x 10"	1.4–2.7	Yes Intermittent	Limited basis	L. E. Dunn, Chief Engineering Test Subdivision
***Martin SS Circuit, Middle River, Md.	16" x 18"	1.5–2.7	Yes; Continuous	No	L. G. Cooper
MIT SS Blowdown, Cambridge, Mass.	14" x 25"	1.3–2.1	Yes; Intermittent	Partial	R. L. Halfman
Michigan U. 8" x 12" SS, Ann Arbor, Mich.	8" x 13"	1.5–4.0	No; Intermittent	Partial	Dr. H. P. Liepman
North American 16" SS, Los Angeles, Calif.	15.75" x 15.75"	0.4–3.75	No; Intermittent	No	
North American High-Flow Blowdown, Los Angeles, Calif.	12" dia., Mach 2.0 18" dia., Mach 1.5	1.5–2.5	Free jet Intermittent	No	
Ohio St. Univ., #2, Columbus, Ohio	12" x 12"	1.4–4.25	Yes; Intermittent	Limited basis	Dept. of Aeronautical Engineering
Ohio St. Univ., #1, Columbus, Ohio	12" x 12"	0.6–3.0	Yes; Intermittent	Limited basis	Same as above
Rosemount Res. Labs. 12" x 12", Minneapolis, Minn.	12" x 12"	2.0–10.0	Yes (to 40 atmos.); Intermittent	Yes	U. of Minn., Dept. of Aero. Eng., Rosemount, Res. Labs.
United Aircraft 17" x 17" SS, E. Hartford, Conn.	17" x 17"	1.4–5.0	Yes (20 atmos.); Intermittent	Limited basis	J. G. Lee, Dir. of Res., UAC.
WAD High-Pressure Air Facility, Wood Ridge, N. J.	10" x 10"	3.22	Yes (125 psia); Intermittent	Not at present	J. Kim, Mgr., Test Instrumentation & Equip. Div.
BPI SS #1, #2, Freeport, N. Y.	10" x 10" 12" x 12" 14" x 14"	2.0–4.0	Yes (600 psia); Intermittent	Yes	Dr. A. Ferri, Dir., Aerodynamics Lab., Polytechnic Inst. of Brooklyn

Abbreviations: TR—Transonic; SS—Supersonic; HT—Hypersonic tunnel; SSFFT—Supersonic free-flight tunnel; NAMTC—Naval Air Missile Test Center; MIT—Mass. Inst. of Technology; DTMB—David Taylor Model Basin (Navy); NOL—Naval Ordnance Laboratory; OAL—Ordnance Aerophysics Laboratory; WADC—Wright Air Development Center (USAF); AEDC GDF—Arnold Engineering Development Center, Gas Dynamics Facility (USAF); NACA—National Advisory Committee for Aeronautics; JPL—Jet Propulsion Laboratory; WAD—Wright Aeronautical Division, Curtiss-Wright Corp.; BPI—Brooklyn Polytechnic Institute

*1956
**Gun-launched model
***1956



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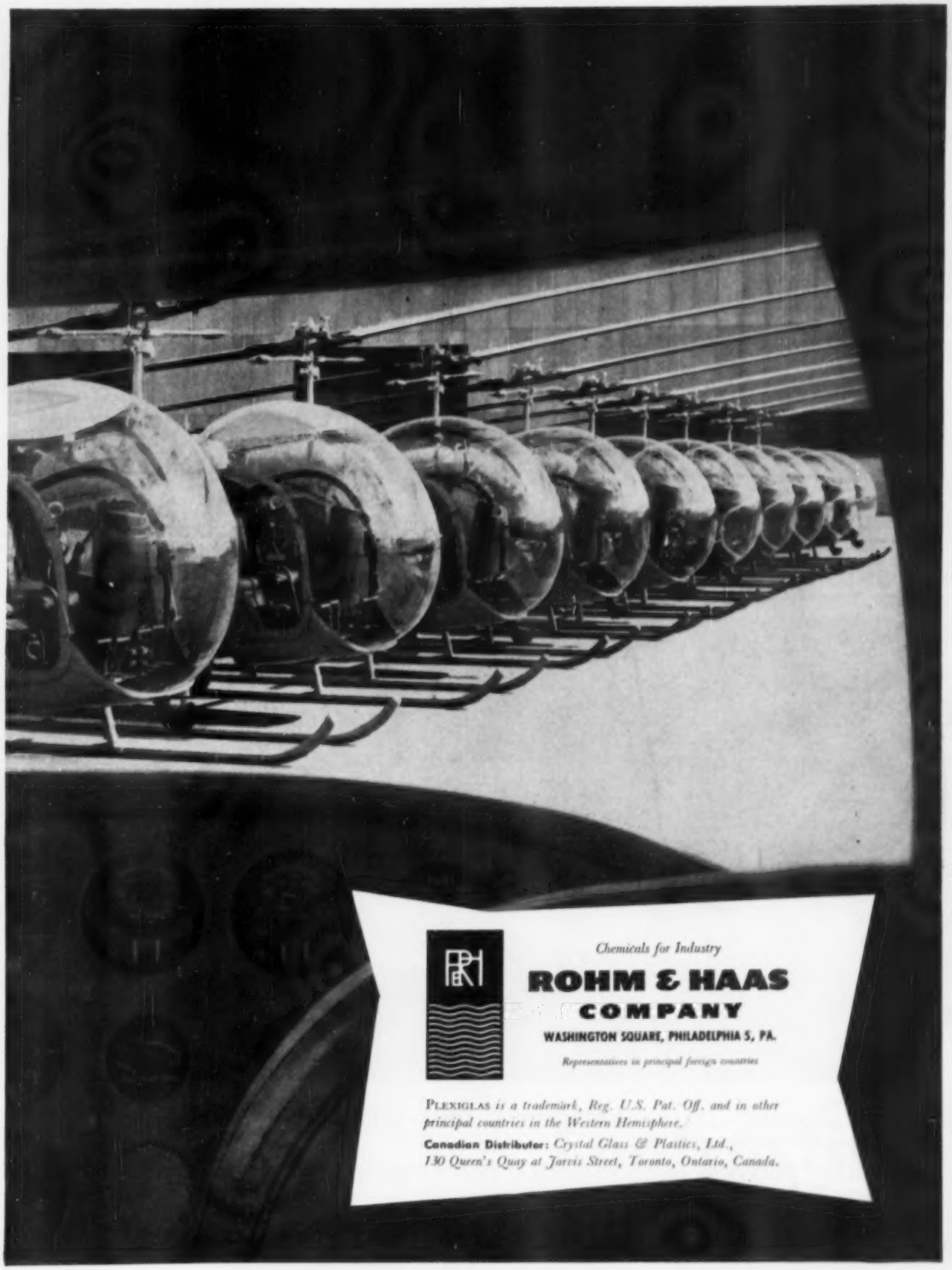
standard transparent plastic

Illustration courtesy of
Bell Aircraft Corporation



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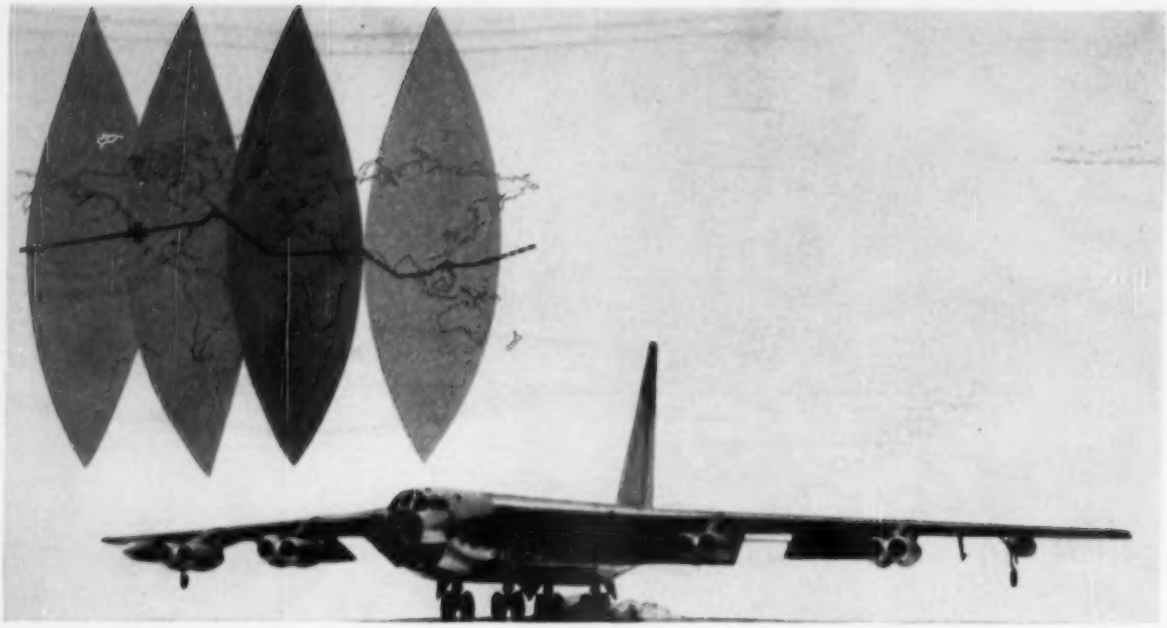

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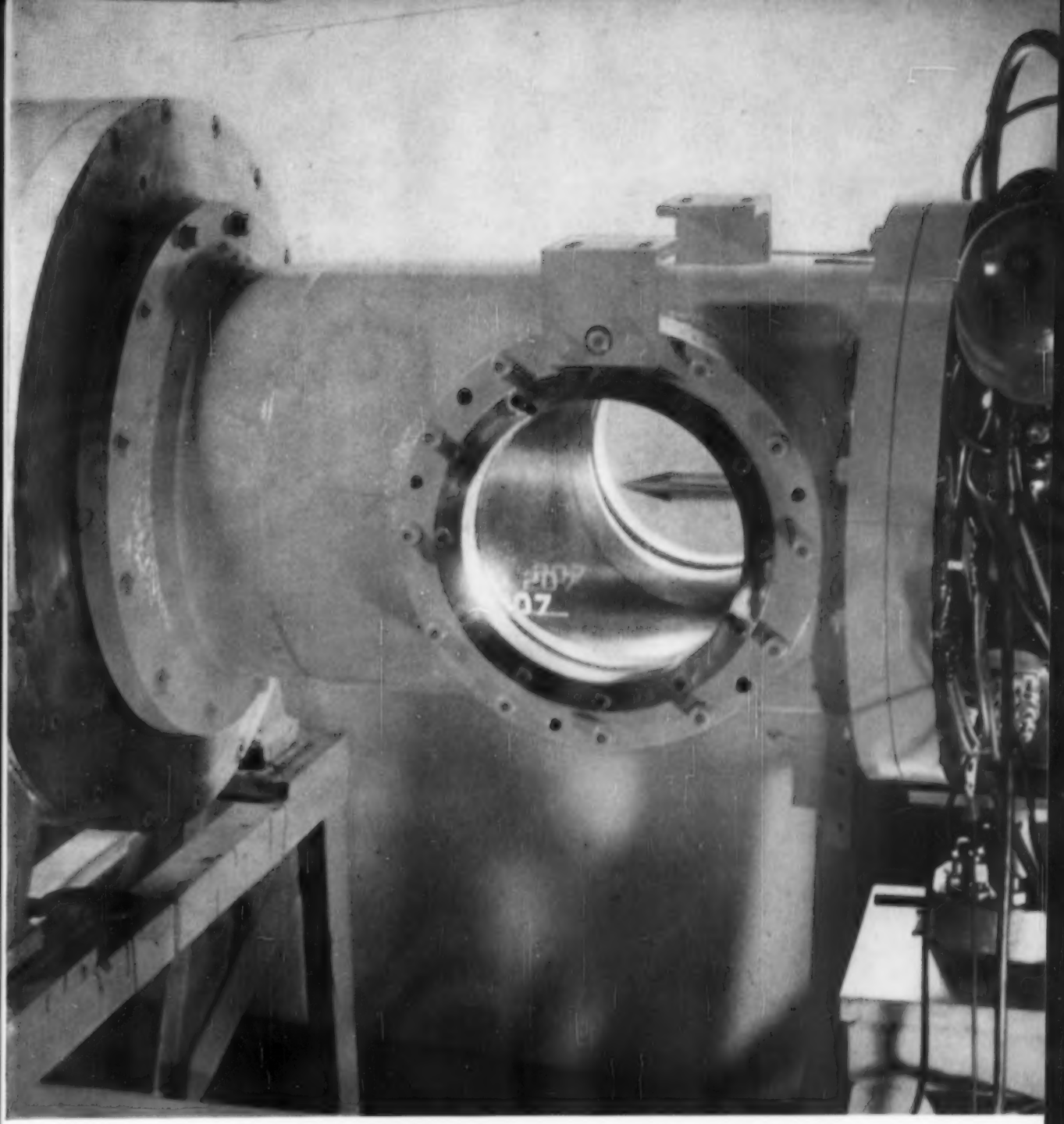
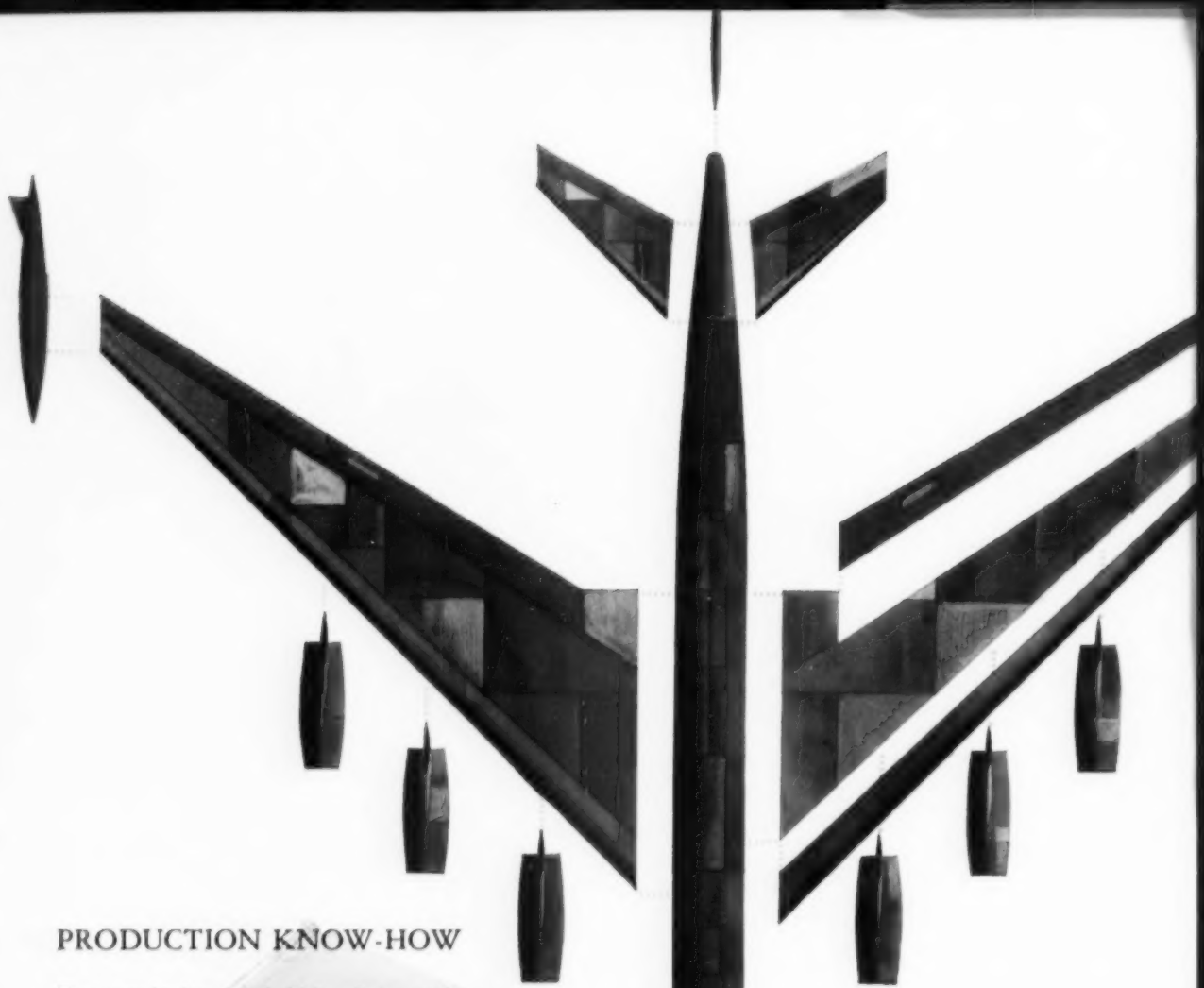


HOTSHOT tunnel at Arnold Engineering Development Center exceeds 11,000 mph. flow, 15,000F.

Contracting



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ONR Guides Navy Contract Research

Washington—Research and development contracting in the Navy is divided into two general areas—basic research and exploratory development, sponsored by the Office of Naval Research, and the follow-up development programs, directed by the Bureaus.

ONR obtains new knowledge and proves new principles. From there on, sponsorship and direction generally are tasks for the operating Bureaus, although ONR now is responsible for overall coordination of both its own research programs and the development work of the bureaus.

Just as direction of the research and development spectrum is divided, so is the type of contracting.

Contractor's Initiative

ONR does not solicit the scientific community in an attempt to find contractors. Initiative must come from the scientist—or university, non-profit laboratory or industrial laboratory—in the form of a proposal. This should include a reasonably complete technical description of the proposed investigation, background of the principal investigator, and resume of the investigative approach and methods to be employed.

About four-fifths of ONR's research is carried on through this contract program, with the rest being done in Navy laboratories. ONR also does a small amount of applied research aimed at developing materials and equipments.

Most of the effort beyond fundamental research, however, is the province of the Bureaus—principally Bureau of Aeronautics, Bureau of Ordnance and Bureau of Ships.

In this area, physical size of the research task and availability of facilities for research and for production of experimental or prototype models assumes more importance.

Bureau Contracting

Contracting procedure broadens from one in which the researcher seeks out the sponsor, to one in which the Bureaus may contact as many known potential contractors as possible, and make the award after competitive negotiation.

At the same time, the Bureaus welcome anyone who can tell them how to obtain better development results more rapidly, cut costs, and build better equipment.

Bureau of Aeronautics is typical of Navy's approach to small business. It has a separate office in charge of Comdr. D. S. Good, which has the responsibility of facilitating small business contacts by making contract information and general problem areas known to interested small firms.

In a great many of BuAer's development contracts, as in ONR's research contracts, initiative is that of the contractor. Once this contact is made, offices such as Cmdr. Good's expedite applications to early decisions.

Detailed Proposals

Prospective contractors should first send the Small Business Office complete information concerning the type of service or product they feel will benefit Navy. This information should be prepared in detail because it will be sent immediately to cognizant technical personnel for their opinion.

BuAer representatives will ask for complete descriptions of facilities, personnel, general activities, etc. This will determine whether a contractor qualifies for placement on BuAer's bidders' list, to be considered for future contracts in case the original suggestion proves unfruitful.

Primary suggestion that BuAer has for prospective small contractors is to forget about a sales campaign. Navy is sold on doing business with small firms and the most rapid approach is through its established organization to the proper technical experts.

These technical men make the decisions regarding applications and idea, so it benefits the small businessman to send his best technical representatives to present the idea to the Navy.

In development contracting, Navy gives considerable consideration to size and availability of facilities. Precision with which the work can be done also becomes a consideration.

The importance of being on the Navy's bidders' list is greater in the development field. Public law as well as Naval regulations specify in many cases that work initiated by the Navy must be placed up for bids. Inclusion on the bidders' list insures that all of this information is available to the small firm. It also insures that Navy's prime contractors have received information of the small firm's capabilities. This opens a whole new field of possible contracts to the small businessman.

General Procurement Policy

The services and major industry began the policy of using many suppliers of products and services to meet the supply and development problems of World War II. During this period many small firms received considerable help in setting up business, even though there was no established policy along this line.

Navy has had a formal small business policy and organization since 1951, in an attempt to insure that small firms get an equitable opportunity to compete for Navy business. Top Navy officials have constantly urged their prime contractors to sub-contract on the widest scale possible.

Navy has expended great effort in supplying prime and sub-contractors with the information required for rapid and efficient sub-contracting, but it does not take part in selection of sub-contractors by a prime.

Navy's efforts to keep a substantial portion of its dollar volume of research and development funds in the hands of small business are hampered by several conditions beyond its control. Unfortunately, much of the development work which is necessary today requires a great amount of expensive equipment and large numbers of men. This unavoidable by-product of the complexity of modern weapon systems has meant that only large companies have been able to afford the necessary men and equipment. It has also meant that over the years the big companies tend to get bigger.

Another factor is the rapid growth of successful small companies, which takes them out of the small business category (500 employees or less). Many small firms in recent years have been able to use good original ideas or designs and rapidly expand into major companies. McDonnell, Piasecki, and Kaman are three of the more spectacular successes.

OFFICE OF NAVAL RESEARCH

AREAS OF RESEARCH

1. Properties of metals and alloys
2. Ceramics and mineral products
3. Electromagnetic waves and propagation
4. Aeromechanics
5. Corrosion mechanisms and prevention
6. High temperature resistant metals
7. Combustion dynamics
8. Inorganic chemistry
9. Physical electronics
10. Electronic components
11. Communications and information theory
12. Structural mechanics and vibration
13. Compilation of scientific data on titanium
14. Extractive metallurgy of titanium
15. Preparation and properties of chemical materials
16. Physical electronics
17. Human engineering in equipment design
18. Propulsive systems for aircraft
19. Fundamental processes in jet propulsion
20. Helicopters
21. Slow speed flight
22. Psychophysiological factors in human tasks
23. Physiological and psychological effects of high intensity noise
24. Psychophysiology of sensory mechanisms
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32. Biological aspects of operational and environmental stresses ■

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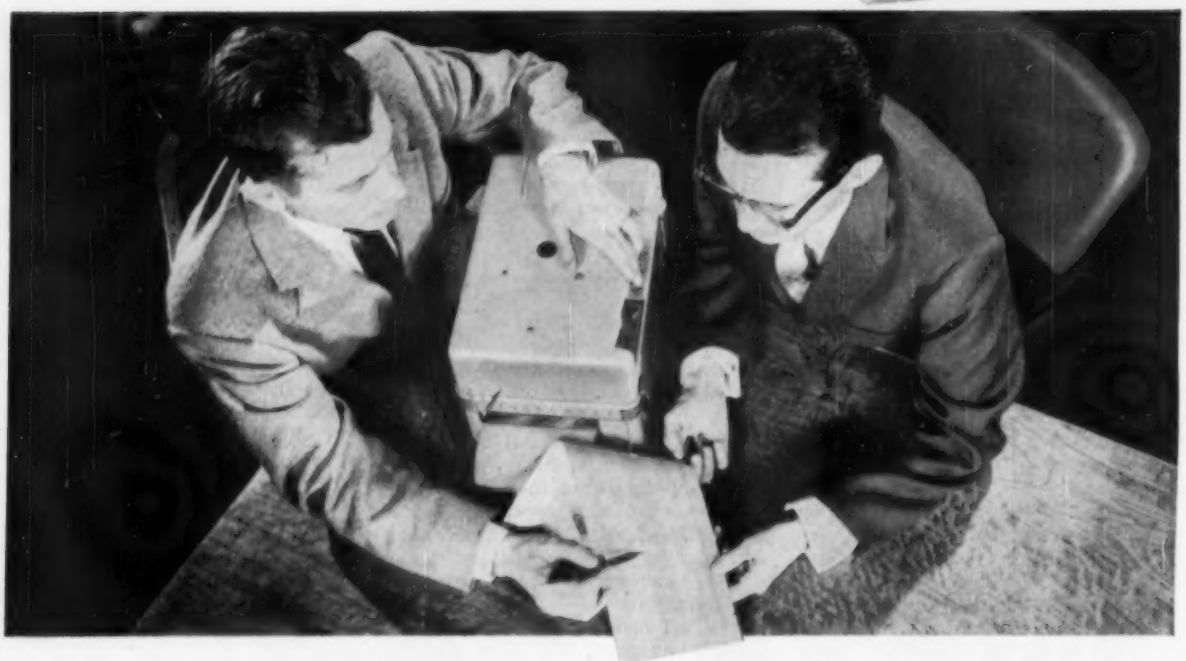

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Circle Number 317 on Reader-Service Card

NACA Research Aided by Contracts

Washington—National Advisory Committee for Aeronautics complements the research done in its three laboratories and two research stations by contracting with some 30 universities and non-profit laboratories.

To obtain its overall objective of providing the new scientific knowledge essential to U.S. leadership in aeronautics, it conducts more than 60 different investigations a year with these contractors.

Contract Average Is $23,000

Contracts range from $1,500 to $50,000 and the average is just under $23,000.

Contract research funds in Fiscal 1957 totaled more than $900,000.

NACA's criterion for deciding to contract out research and for choosing the researcher to do it is specialized capability.

Contracts are negotiated with universities or laboratories having either specialized research facilities or scientists of outstanding ability that is not otherwise available for investigating technical problems of particular aeronautical importance.

Proposals must be submitted by the potential contractor, although the initiative may have been either NACA's or that of the investigator.

NACA staff members and the appropriate technical subcommittees review all proposals. Since industry and the services are broadly represented on the subcommittees by technical specialists, these reviews insure that the proposals finally accepted are technically sound and cover problems of highest interest to the potential users of the research results.

NACA's contract research program is an integral part of the agency's overall research effort. Studies are related to the program in a manner similar to integration of the laboratory programs.

Reports on useful results of this contracted research are prepared to the same high standards as other NACA reports, and are given the same distribution to insure maximum usefulness and availability.

A complete list of NACA's technical fields of interest and another including NACA contractors appear in this section. Below is a list of committees and subcommittees which plan and initiate some of the research contract work, and review proposals:

Aerodynamics Committee

Committee on Aerodynamics consists of these subcommittees:

- Fluid Mechanics.
- High-Speed Aerodynamics.
- Aerodynamic Stability and Control.
- Automatic Stabilization and Control.
- Internal Flow.
- Propellers for Aircraft.
- Seaplanes
- Helicopters.

Aircraft Powerplant Committee

Committee on Powerplants for Aircraft consists of these subcommittees:

- Aircraft Fuels.
- Combustion.
- Lubrication and Wear.
- Compressors and Turbines.
- Engine Performance and Operation
- Powerplant Controls.
- Powerplant Materials.
- Rocket Engines.

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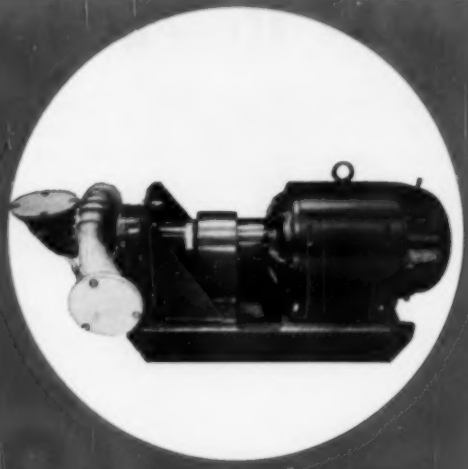
EL 1000—LOX

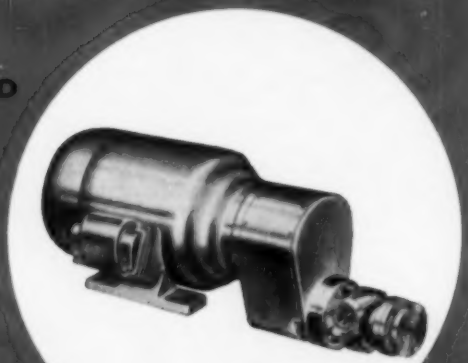
1000 GPM	400 ft. Head
16 Ft. NPSH	125 H.P.
Weight of Pump and Drive	60 lbs.



MEDIUM FLOW • MEDIUM HEAD

ECMP 35-30 LOX/ARGON/NITROGEN

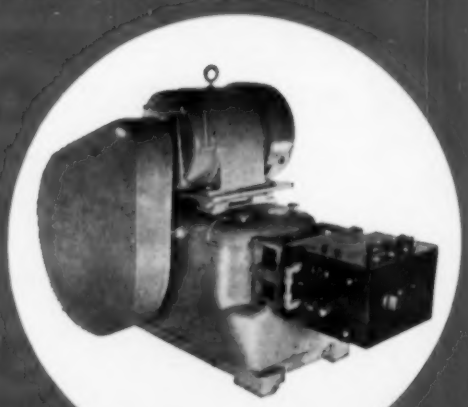
35 GPM	600 Ft. Head
50 GPM	500 Ft. Head
3½ Ft. NPSH	10 H.P.
Weight of Pump and Drive	8 lbs.



LOW FLOW • HIGH HEAD

EHP 80-55 NITROGEN/OXYGEN

1½-8 GPM	2000-5500 psi
10 Ft. NPSH	10 H.P.
Weight of Pump and Drive	1600 lbs.



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Aircraft Construction Committee

Committee on Aircraft Construction is made up of these subcommittees:

- **Aircraft Structures.**
- **Aircraft Loads.**
- **Vibration and Flutter.**
- **Aircraft Structural Material.**

Operating Problems Committee

Committee on Operating Problems includes these subcommittees:

- **Meteorological Problems.**
- **Icing Problems.**
- **Flight Safety.**
- **Aircraft Noise.**

In Fiscal 1956, NACA obligated a total of $233,402 to 16 contractors for investigations in the field of aerodynamics; $183,487 to 11 contractors for powerplant work; $244,866 to 10 contractors for investigations in aircraft construction problems, and $88,536 to three institutions for research on operating problems.

Estimated obligations for Fiscal 1957 totaled $770,000.

Requests for further information or specific proposals should be sent to National Advisory Committee for Aeronautics, Headquarters, 1512 H Street N.W., Washington 25, D.C., and addressed to the attention of the technical subcommittee concerned with the particular research field.

TECHNICAL FIELDS OF INTEREST

1 **AERODYNAMICS**

1 **FLUID MECHANICS**

1. Aerodynamic heating at high Mach numbers
2. Transition from laminar to turbulent flow in boundary layers
3. Skin friction
4. Physical and chemical properties of air at high temperatures
5. Shock waves and their interaction with boundary layers

2 **HIGH-SPEED AERODYNAMICS**

1. Supersonic pressure phenomena
   1. Interference of aircraft components
   2. Inlet location
   3. Jet exit location
   4. Lift development
2. Friction drag and aerodynamic heating
   1. Maintenance of laminar flow
   2. Factors affecting boundary layer transition

3 **AERODYNAMICS STABILITY AND CONTROL**

1. Mach number, angle of attack effects on static stability
2. Mach number, altitude effects on dynamic stability
3. Effective aircraft control through Mach number range
4. Stall improvements for high performance aircraft
5. Recovery from spins
6. Flying qualities of high performance configurations

4 **AUTOMATIC STABILIZATION AND CONTROL**

1. Powered controls
2. Artificial stabilization and motion limiting
3. Human pilot control and tracking capabilities
4. Control through automatic pilots
5. Automatic tracking

5 **INTERNAL FLOW**

1. Inlets
   1. Design
   2. Location
   3. Inlet-engine matching
   4. Variable geometry and controls
2. Ducts and diffusers
   1. Separation phenomena
   2. Transition phenomena
   3. Design criteria
3. Jet exits
   1. Design criteria
   2. Jet interference with aircraft components
4. Auxiliary inlets and exits
5. Thrust reversers
6. Noise suppressors

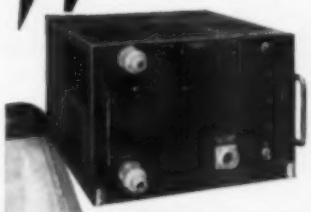
6 **AERODYNAMICS OF LOW SPEED FLIGHT**

1. Helicopters
   1. High-speed rotors
   2. Stability and control characteristics
   3. Instrument flight
2. VTOL/STOL aircraft
   1. General aerodynamics
   2. Stability and control
3. Lift augmentation
   1. Boundary layer control
   2. Jet flaps
   3. High lift devices applied to high-speed aircraft
4. Propellers
   1. VTOL/STOL aircraft types
   2. Supersonic propellers
5. Water-based aircraft
   1. Aerodynamics and hydrodynamics of high-speed seaplanes
   2. Seaplane rough-water capabilities
   3. Hydrodynamic lift/drag efficiency
      1. Hulls
      2. Hydrofoils
      3. Hydro-skis
   4. Spray and flow phenomena
   5. Hydrodynamic stability, control and handling qualities
6. Research equipment and techniques

POWER PLANTS FOR AIRCRAFT

1. Propulsion system performance
   1. Rockets
   2. Nuclear systems
   3. Ramjets
   4. Gas turbine systems
   5. Hybrid cycles
   6. Inlet and exit systems
   7. Controls

Who put out the "fire" in the tail?



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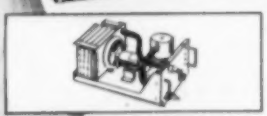

Tested, proven, set for mass production — Hallicrafters new Models CR-2, CR-5 and CR-7 airborne cooling units meet environmental conditions of MIL-E-5272 specification. Revolutionary design permits use of standard racks (CR-7 dimensions: 15⅜" x 19 9/16" x 10⅝") and also accommodates whatever auxiliary gear, such as relays and switches, you may desire.

Vital weight factor is another advantage. For instance: the CR-5 weighs just *30* lbs., is *30% lighter* than conventional 5,000 watt units. And your choice of cooling fluids gives great flexibility of application: silicone oil; ethylene-glycol solution; hydraulic fluid.

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2. *Self-actuating temperature by-pass valve.* Permits predetermination of optimum liquid temperature and control within very close limits ±2° C.

3. *Flow control valve.* Exclusive new Hallicrafters device operates independently of system pressure, supplies emergency shut off of Electronic Equipment in event of pump failure or blockage.

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Where Do Great Ideas Come From?

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So, at the very core of our progress is the college classroom. It is there that the imagination of young men and women gains the intellectual discipline that turns it to useful thinking. It is there that the great ideas of the future will be born.

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Sponsored as a public service, in cooperation with the Council for Financial Aid to Education

2. Propellants
   1. Performance calculation and evaluation
   2. Thermal properties
   3. Synthesis and analysis
3. Compressors and turbines
   1. Compressors
   2. Turbine aerodynamics
   3. Turbine cooling
   4. Blade vibration and flutter
   5. Heat transfer
4. Combustion
   1. Fundamentals
   2. Combustion chambers
5. Lubrication and wear
   1. Fundamentals of friction and wear
   2. Bearing research
6. Materials
   1. High temperature materials
   2. Stresses research
   3. Physics of solids
7. Research equipment and techniques

3 AIRCRAFT CONSTRUCTION

1. Aircraft structures
   1. Static properties
   2. Dynamic properties
   3. Fatigue properties
   4. Thermal properties
2. Aircraft loads
1. Basic air loads distribution
   1. Complete airplanes
   2. Lifting and stabilizing surfaces
   3. Control devices
   4. Leading edge devices
   5. Isolated bodies
2. Loads associated with maneuvers
   1. Critical operating conditions
   2. Maneuver and motion studies
3. Dynamic loads
   1. Gust loads
   2. Buffeting loads
   3. Blast loads
   4. Loads due to high intensity noise
4. Landing and taxi loads
   1. Initial landing impact and associated conditions
   2. Ground handling and taxi
   3. Landing gear component characteristics
   4. Hydrodynamic impact
5. Miscellaneous
6. Vibration and flutter
   1. Aerodynamics of unsteady flow
      1. Airfoils
      2. Airfoils with control surfaces
      3. Complete configurations
   2. Flutter
      1. Theory and methods of analysis
      2. Experiments on airfoils
      3. Experiments on airfoils with control surfaces
      4. Experiments on airfoils on complete configurations
   3. Vibration
      1. Airframes
      2. Power plants
      3. Landing gears
   4. Phenomena involving separated flow
      1. Buffeting
      2. Stall flutter
      3. Transonic flutter
   5. Miscellaneous
7. Aircraft structural materials
   1. Structural materials at high temperatures
   2. Fatigue
   3. Plastic behavior of metals
   4. Non-metallic materials
8. Research equipment and techniques

4 OPERATING PROBLEMS

1. Aircraft noise
   1. Jet noise
   2. Boundary layer noise
   3. Propeller noise
   4. Effects of noise on structures
   5. Attenuation of noise
2. Flight safety
   1. Landing problems
   2. Fire
   3. Gust alleviation
   4. Optimum flight paths
   5. Airspeed measuring systems
   6. Spin hazards and recovery
   7. Engine performance and reliability
   8. Precision of instrument flight in helicopters
   9. Thrust reversal
   10. Foreign object damage to engines
   11. Pilot escape
   12. Crash survival
   13. Ditching
3. Aeronautical meteorology
   1. Atmospheric turbulence
   2. Characteristics of icing clouds
4. Icing problems
   1. Droplet impingement
   2. Icing protection
5. Research equipment and techniques ■

AMERICAN ELECTRONICS, INC.

ANNOUNCING
RADIFLO

...a revolutionary system for detecting leaks in transistors, diodes and other sealed units for pennies each!

RADIFLO offers a vast improvement over present leak detection methods because it measures the leak after the final sealing operation is completed. RADIFLO eliminates most of the expensive labor cost... *yet gives the same or greater accuracy in a fraction of the time!*

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Tests have shown that transistors can be checked at a cost as low as two cents each with corresponding savings on other types of parts. RADIFLO can also be easily set up on an assembly line for automatic parts inspection.

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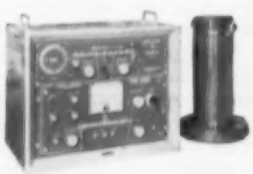

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How ARDC 'Buys' Scientific Ideas

Baltimore—Air Research and Development Command's mission of providing qualitatively superior airpower demands that it procure the highest in technical competence.

In buying research and development effort in the short but vital creative end of the air weapons spectrum, it is attempting to outstrip a potential enemy who has shown surprising ability in scientific and technical fields.

Key factor in ARDC's formula for producing qualitative superiority in USAF's men and machines is communications with its contractors. For the past two years ARDC has made an increasingly strong effort to tell universities, scientific laboratories and industry what Air Force's needs are now, and what they are likely to be well into the future, and how the ARDC-science-industry team can meet them.

Because it is primarily in the business of buying ideas, the command recognizes that the communications circuit must work two ways. Increasingly in recent years, ARDC has found itself asking industry what weapon systems or weapon system concepts might fulfill USAF's projected requirements, rather than telling industry what to develop.

Communications Network

Necessity for this effective communications network between the command, its 11 centers, and the scientific and industrial talents of the nation is clear.

Industry employs two-thirds of the 250,000 people working at the professional level in the natural sciences and three-fourths of the nation's 700,000 engineers, according to ARDC manpower and personnel experts.

Even though ARDC maintains a string of research, development and testing bases across the nation, three-fourths of the research and development effort going into Air Force hardware is done on contract, by universities, private research foundations, and firms ranging almost all the way across the industrial board.

Bulk of the contracts are written at the centers themselves. These centers serve as contact points for contractors, give guidance throughout the life of the contract and, in many cases, provide facilities where new ideas can be explored and developmental items tested.

ARDC's mission is broken down into two general areas—a Technical Program and an Operational Program. Technical Program begins with research and grows into technical development or exploratory development, dealing with weapons and weapon systems needed one to two decades from now.

Operational Program is concerned basically with weapons systems that will join the Air Force inventory within the next three-quarters of a decade.

Three main methods are used to acquaint science and industry with ARDC's thinking.

Technical Planning Documents

Technical Program Planning Documents are the first. These are classified studies establishing and delineating Air Force's technical requirements and objectives over a period that could be called the immediate future.

TPPDs cover 46 broad functional areas such as stragetic bombing, missile guidance, electronic countermeasures, etc.

They define the job Air Force will have to do 10 to 20 years from now; evaluate present technical capability in the area concerned, and note limitations of current materiel and techniques; give pertinent research summaries, proposed innovations and suggested approaches; and present ARDC's technical requirements and performance objectives.

Technical Program Planning Documents originally were distributed to contractors selected for ARDC by the ARDC-Air Materiel Command Source Selection Board. Now, however, ARDC solicits queries and requests from potential sources of research and development who are not currently contracting with USAF.

(See Technical Fields of Interest List and tear-out source questionnaire in this section.)

Weapon Systems Requirements

Weapon Systems Requirements, now being released to qualified contractors within the existing security framework, are an attempt to let industry in on USAF and ARDC planning secrets.

ARDC admits that one of its goals is to get industry to do more of its own research and development. But this method also overcomes a former paradox of conducting business in classified areas.

At one time a contractor needed a contract in order to get information, and he needed information in order to get a contract.

Distribution of the Systems Requirements documents still depends upon a "need to know"—but ARDC defines this as integrity, plus a capability to participate in the research and development effort.

In discussing these requirements, ARDC deals with a company's vice president for engineering or his equivalent. Conferences may be arranged by writing to the Program Plans and Policies Office (RDZPP) at ARDC headquarters. Requirements attempt to explain what Air Force wants to know about potential future weapon system areas.

Contractors select areas in which they believe they can make contributions.

Technical Symposia

Technical Program Symposia and Weapons Systems Conferences basically are implementations of the philosophy behind the TPPDs and WSRs—a philosophy of comprehensive, integrated ARDC-industry effort, based on mutual confidence.

An even newer channel for communicating with industry is the Office of Executive for Small Business, created late last year in the Procurement Directorate at ARDC Headquarters.

The ESB has established a one-stop counseling service for small firms at each center and at Field Development offices in New York, Los Angeles, Boston and Chicago. Small business specialists are at each location. At centers, they are located administratively on the staff of the Director of Procurement.

Small business is defined by ARDC as a firm that is not dominant in its fields of operations, and which does not employ more than 500, either by itself or with its affiliates.

ARDC constantly looks for new sources of technical competence. Contractors eventually will deal with a center, where almost all contracts are written and monitored, but information on how to join the list of ARDC contractors is available both at the centers and at headquarters.

Contact at the centers is the Contractor Relations Office. Contact at headquarters is Office of Industrial Relations for personal visits, or Commander, ARDC, Box 1395, Baltimore 3, Md., Attention: RDSKM, for mail inquiries.

Production of superior air weapon systems as a final product means superior raw materials in the beginning. For ARDC, this means primarily the talent of the men in the organizations with which it deals, and secondarily, their facilities.

The command, the Procurement Directorate at headquarters, and the centers all stress both a potential research and development contractor's competence in past investigations and his approach to the present technical problem. ■

TECHNICAL FIELDS OF INTEREST

AIR RESEARCH AND DEVELOPMENT COMMAND

Through the cooperation of AVIATION WEEK, the Air Research and Development Command is conducting a survey to determine this country's untapped research and development potential.

The information obtained will be entered in the proper ARDC Center Source Files and all firms so entered will be considered for future Air Force Research and Development programs.

All organizations or institutions interested in contracting for ARDC are requested to complete the inclosed "tear-out" source form and return it to the proper ARDC center, Attn.: Contractor Relations Branch with technical resumes and brochures.

If your company does no research or development work, or has no facilities for research work, please do not complete this form. If your company has sent in similar information within the past year, do not complete the form.

Your reply, of course, will not obligate your company, ARDC or AVIATION WEEK in any way.

1 AIRCRAFT AND FLIGHT EQUIPMENT

- **1 AIRCRAFT INSTRUMENTS**
  1. Position-indicating devices
  2. Engine
  3. Flight
  4. Navigation
  5. Flight test
  6. Data presentation
- **2 AIRCRAFT DESIGN**
  1. Aerodynamic configuration
  2. Control systems
  3. Stability augmenters
  4. Special type aircraft
- **3 AIRCRAFT STRUCTURES**
  1. Theory
  2. Design
  3. Testing
  4. Stress analysis
  5. Criteria
- **4 FLIGHT OPERATING PROBLEMS**
  1. Flight planning
  2. Special techniques
  3. Meteorological aspects
- **5 FLIGHT SAFETY**
  1. Approach visibility
  2. Turbulence (storm and clear air)
- **6 GLIDERS**
- **7 LIGHTER-THAN-AIR**
  1. Balloon components
  2. Tracking
  3. Air launch balloons
  4. Sounding balloons
- **8 PROPELLERS AND ROTORS**
  1. Application and performance studies
     1—Conventional, high subsonic
     2—Vertical take off, helicopters
     3—Short take off, landing
     4—Converting vertical—horizontal
     5—Supersonic
  2. Design and development
     1—Blade and hub structures
     2—Pitch change and control
     3—Accessories
     4—Test facilities
- **9 ROTATING—WING AIRCRAFT**
  1. Aerodynamics
  2. Performance
  3. Stability and control
  4. Design criteria
- **10 WATER BORNE AIRCRAFT**
  1. Hydro-skis
  2. Floats

2 ASTRONOMY, GEOPHYSICS, AND GEOGRAPHY

- **1 ASTRONOMY**
  1. Solar Phenomena
  2. Stellar scintillation
- **2 CARTOGRAPHY**
- **3 CLIMATOLOGY**
- **4 GEODETIC ENGINEERING**
  1. Gravity measurement
  2. Solar and lunar eclipse
- **5 GEOGRAPHY**
- **6 GEOMAGNETISM**
- **7 METEOROLOGY**
  1. Radiosondes
  2. Air sampling equipment
  3. Recorders
- **8 MINEROLOGY**
- **9 OCEANOGRAPHY**
  1. Arctic
  2. Tropic
- **10 SEISMOLOGY**

3 CHEMICAL WARFARE EQUIPMENT AND MATERIALS

- **1 BIOLOGICAL AGENTS**
- **3 INCENDIARIES**
- **4 PROTECTION AND DECONTAMINATION**
- **5 PYROTECHNICS**
- **6 SCREENING AGENTS AND SMOKES**
- **7 WAR GASES**

4 CHEMISTRY

- **1 CHEMICAL ENGINEERING**
- **2 INORGANIC CHEMISTRY**
- **3 ORGANIC CHEMISTRY**
  1. Surface chemistry
  2. Polymer chemistry
- **4 PHYSICAL CHEMISTRY**
  1. Photo chemistry
  2. Atmospheric Ozone
  3. Air glow
  4. Radiation
  5. Combustion
- **5 ANALYTICAL CHEMISTRY**

5 COMMUNICATIONS

- **1 COMBAT INFORMATION CENTERS**
  1. Data transmission systems—digital
  2. Data transmission systems—analog
  3. Plotting boards and computers
  4. Video transmission systems engineering
     1—Transmitters
     2—Receivers
     3—Displays
  5. Telephone, repeater, multiplex, and teletype systems engineering
     1—Telephone and telephone circuits
     2—Teletype, repeaters, perforators, reperforators
     3—Switch boards
     4—Multiplex
     5—Central office
     6—Switching devices
     7—Cables
     8—Facsimile—high speed printing and scanning
- **2 RADIO COMMUNICATIONS**
  1. Microwave systems
  2. Long range fixed plant communication engineering
  3. Short and medium range fixed plant communication engineering
  4. Mobile communication systems engineering
  5. Propagation engineering
  6. Transmitters
     1—LF, Low and high power; amplitude and FM
     2—MF, Low and high power; amplitude and FM
     3—HF, Low and high power; amplitude and FM
     4—VHF, Low and high power; amplitude and FM
     5—UHF, Low and high power; amplitude and FM
     6—SHF, Low and high power; amplitude and FM
     7—Single sideband
     8—Synchronous detection
     9—Pulse
     10—RF amplifiers
  7. Receivers
     1—LF, MF, HF, VHF, UHF, SHF
     2—Single sideband
     3—Synchronous detection
     4—Pulse
  8. Anti-jam techniques and equipment
  9. Interference elimination and suppression, blankers and delay lines
  10. Ionospheric characteristic
  11. Telemetering
  12. Mathematical Theory of communications and related studies
  13. Cryptography
  14. Data link
- **3 SOUND RECORDING AND AMPLIFICATIONS**
  1. Audio equipment
     1—Recorders and reproducers
     2—Audio amplifiers
     3—Speakers
     4—Microphones
     5—Headsets
     6—Speech compression
     7—Keyers
- **4 TELEVISION**
- **5 WIRE COMMUNICATIONS**

6 DETECTION

- **1 ACOUSTIC**
  1. Microwave panoramic type receivers
  2. VHF-UHF panoramic receivers
  3. Microwave instantaneous signal and frequency analysis equipment
  4. Droppable intelligence sensors-acoustic
- **2 DIRECTION FINDERS**
  1. Communications equipment—LF, MF, HF, VHF, UHF, SHF
- **3 INFRARED**
  1. Detection equipment—passive
  2. Star scintillation studies
  3. Application to Missile homing
  4. Theoretical studies
  5. Infrared spectroscopy
- **4 MAGNETIC**
  1. Passive detection
     1—Broadband microwave antennas
     2—Broadband VHF-UHF antennas
     3—Microwave panoramic type receivers
     4—VHF-UHF panoramic receivers
     5—Microwave instantaneous signal and frequency analysis equipment
     6—VHF-UHF instantaneous signal and frequency analysis equipment
- **5 OPTICAL**
  1. Countermeasure devices
  2. Optical radar
     1—High energy gas discharge
     2—Other high energy light sources and usages
- **6 RADAR AND RADIO**
  1. Long range systems, fixed
  2. Long range systems, mobile
  3. Medium range control and guidance
  4. Short range precision
  5. Transmitters
     1—Magnetron
     2—Klystron
     3—Vacuum tube
     4—Driver chains
  6. Modulators
     1—Magnetic
     2—Thyratron
     3—Spark gap
     4—Hard tube
  7. Receivers
     1—Duplexer
     2—TRs
     3—Mixers
     4—Amplifiers
     5—Special, FM stacked beams
     6—New techniques
  8. Moving target equipment
     1—Delay lines
     2—Integrators
     3—Cancellation units
     4—MTI test equipment
     5—New techniques
  9. Processing equipment indicators
     1—Cathode ray
     2—Monitor
     3—Projection
  10. Display
     1—Plotting
     2—Situation
     3—Projection
     4—Combining
  11. Tracking equipment
     1—Magnetic
     2—Electronic
     3—Transistor
  12. Anti-jam techniques and equipment
  13. Radar techniques
     1—Pulse doppler radar
     2—Aural radar presentation
     3—Beam splitting
     4—Track-while-scan techniques
  14. Target reflection studies
     1—Radar reflection of birds, etc.
     2—Radar cross section
     3—Radar camouflage
     4—Detection decoys

7 ELECTRICAL EQUIPMENT

- **1 BATTERIES**

(Continued on next page)

Div Sec

2 **CONTROL AND PROTECTIVE EQUIPMENT**
1. Electrical control equipment
2. Frequency synthesizers and oscillators
3. Security devices (cryptographic)

3 **DISTRIBUTION EQUIPMENT**

4 **HEATING AND LIGHTING EQUIPMENT**
1. Heating devices

5 **POWER EQUIPMENT**
1. Motor generators
2. Gas
3. Diesel

8 **ELECTRONICS AND ELECTRONIC EQUIPMENT**

1 **ANTENNAS**
1. Broadband microwave antennas
2. Broadband VHF-UHF antennas
3. LF, MF, VHF, UHF, SHF directional and Omni-directional
4. High-speed
5. High-definition
6. Microwave
7. Special
8. Antenna couplers
9. Masts and towers
10. Pedestals
11. Reflector-structures
12. Feed systems
13. Towers
14. Radomes
15. Diplexers
16. Transmission lines (RF)
17. Antenna drive systems

2 **ACCESSORIES**
1. Power supplies—AC and DC regulated and unregulated, dynamotors, generators

3 **COMPONENTS**
1. Power, audio and RF transformers and inductors
2. Circuit breakers
3. Relays
4. Metallic rectifiers
5. Motors
6. RF power and control cables and connectors
7. Magnet and hook-up wire
8. Meters
9. Switches
10. Sockets
11. Capacitors
12. Resistors

4 **ELECTRONIC TUBE DEVICES**
1. Klystrons
2. Magnetrons—carcinotrons, stabilitrons

5 **MODULATION STUDIES**

6 **WAVE PROPAGATION**
1. Tropospheric
2. Ionospheric
3. Meteoric
4. Special areas of study

7 **COUNTERMEASURES**
1. Electronic warfare system studies
2. Jammers
   1—Broadband microwave transmitting tubes—Carcinotrons
   2—Broadband UHF-VHF transmitting tubes
   3—Noise generators
3. Decoys (Microwave)
   1—Corner reflectors
   2—Camouflage—absorbing materials, reflecting materials, chaff
   3—Interrogator—responder beacons

8 **ELECTRONIC THEORY**

9 **ELECTRONIC TEST EQUIPMENT**

9 **FLUID MECHANICS**

1 **DYNAMICS**

2 **COMPRESSIBILITY**

3 **STATICS**

4 **HYDRODYNAMICS**

5 **THERMOAERODYNAMICS**

6 **THEORETICAL AERODYNAMICS**

7 **EXPERIMENTAL AERODYNAMICS**

10 **FUELS AND COMBUSTION**

1 **GASEOUS FUELS**

2 **LIQUID FUELS**

3 **SOLID FUELS**

4 **GASEOUS PROPELLANTS**

5 **LIQUID PROPELLANTS**

6 **SOLID PROPELLANTS**

7 **COMBUSTION**

11 **GROUND TRANSPORTATION EQUIPMENT**

1 **AMPHIBIOUS VEHICLES**

2 **AUTOMOTIVE PARTS AND ACCESSORIES**

3 **GROUND HANDLING EQUIPMENT**

4 **SPECIAL PURPOSE VEHICLES**
1. Automatic trailers
2. Oxygen-hydrogen—fuel oil
3. Maintenance and repair shops

12 **GUIDED MISSLES**

1 **AERODYNAMICS AND BALLISTICS**

2 **GUIDANCE AND CONTROL**
1. Data storage-processing-transmission
2. New or unusual control systems
3. Inertial, celestial, and other guidance
4. Homing: Infrared, Optical, Thermal, etc.

3 **HANDLING AND LAUNCHING**

4 **PROPULSION**

5 **WARHEADS AND FUSES**

13 **INSTALLATIONS AND CONSTRUCTION**

1 **AIR CONDITIONING AND REFRIGERATION EQUIPMENT**
1. Air cooling devices
2. Heating devices

2 **CONSTRUCTION EQUIPMENT**

3 **SANITATION ENGINEERING**

4 **STRUCTURAL ENGINEERING**
1. Shelters
2. Racks
   1—Mobile
   2—Permanent station
   3—Equipment
3. Transit cases

5 **FORTIFICATIONS**

6 **MILITARY INSTALLATIONS**

7 **PUBLIC UTILITIES**

8 **REPAIR AND MAINTENANCE FACILITIES**

9 **YARDS AND DOCKS**

10 **VULNERABILITY STUDIES**

14 **MATERIALS (NONMETALLIC)**

1 **ADHESIVES AND SEALANTS**

2 **CERAMICS**

3 **HYDRAULIC FLUIDS**

4 **LEATHER AND TEXTILES**

5 **LUBRICANTS**

6 **MISCELLANEOUS MATERIALS**

7 **PAINTS AND FINISHES**

8 **PLASTICS**

9 **RUBBER AND ELASTOMERS**

10 **WOOD**

15 **MATHEMATICS**

1 **PURE MATHEMATICS**

2 **STATISTICS**

16 **MEDICAL SCIENCES**

1 **ANATOMY AND PHYSIOLOGY**

2 **BACTERIOLOGY**

3 **BIOCHEMISTRY**

4 **BIOLOGY**

5 **DENTISTRY**

6 **HYGIENE AND SANITATION**

7 **MEDICAL SPECIALTIES**

8 **MEDICAL SUPPLIES AND EQUIPMENT**

9 **NUTRITION**

10 **PATHOLOGY**

11 **PHARMACOLOGY AND TOXICOLOGY**

12 **PSYCHIATRY AND NEUROLOGY**

13 **SURGERY**

14 **VETERINARY MEDICINE**

15 **VISUAL AND AUDITORY STUDIES**

16 **HUMAN ENGINEERING**

17 **ANTHROPOLOGY**

18 **BIO-ACOUSTICS**

17 **METALLURGY**

1 **MINING AND REFINING**

2 **STRUCTURAL METALLURGY**

3 **BRONZE, BRASS, AND BEARING ALLOYS**

4 **HEAT-RESISTANT ALLOYS**

5 **IRON AND ALLOYS**

6 **LIGHT METALS AND ALLOYS**

7 **MISCELLANEOUS NONFERROUS METALS AND ALLOYS**

18 **MILITARY SCIENCES AND OPERATIONS**

1 **DEFENSE**

2 **INTELLIGENCE**
1. Intelligence sensors
   1—Seismic
   2—Acoustic
   3—Chemical
2. Data handling and display
   1—Storage and retrieval—magnetic, photographic electro-mechanical
   2—Presentation—electronic, photographic, optic
   3—Dissemination and reproduction—magnetic, photographic, lithographic
   4—Conversion (Raw data to processible form)—photographic, electronic, electro-optical

3 **LOGISTICS**

4 **OPERATIONS**
1. Intelligence Parameters Studies
   1—Target analysis
   2—Enemy capabilities
2. Intelligence Systems Studies

5 **ORGANIZATION AND ADMINISTRATION**

6 **PSYCHOLOGICAL WARFARE**

7 **STRATEGY AND TACTICS**

19 **NAVIGATION**

1 **CELESTIAL NAVIGATION**

2 **DEAD RECKONING AND PILOTAGE**

3 **ELECTRONIC NAVIGATION**
1.
   1—Short range hyperbolic systems
   2—Short range phase-matching systems
   3—Long range navigation systems
   4—Medium range control and guidance
2. Remoting
   1—Terminal equipment
   2—Microwave links
   3—Multicouplers
   4—Traveling wave tube
   5—Cable
3. Display equipment
   1—Direct readout
   2—Horizontal
   3—Az-el indicator
   4—Character display
   5—Colored display
   6—Photographic
4. IFF equipment
   1—Interrogators
   2—Responders
   3—Coders
   4—Decoders
   5—Crypto boxes
   6—Indicators
5. Beacons
   1—Lightweight droppable
   2—Tactical X-band
   3—Long life
   6—Signal enhancement
   1—Corner reflectors
   2—Transponders
   3—Crystal enhancer
   4—Signal integrators
7. Time standards
   1—Crystal
   2—Atomic
   3—Molecular
   4—Frequency dividers

4 **INERTIAL SYSTEMS**

5 **NAVIGATIONAL INSTRUMENTS**
1. Very short range high definition landing sets
2. Very short range high definition airport surveillance sets
3. Medium range traffic control surveillance sets
4. Terminal and en route guidance

6 **SPECIAL NAVIGATION SYSTEMS**
1. Equipment and areas of interest
   1—Mobile target indicator—coherent and noncoherent
   2—Circular polarization development
   3—Automatic frequency control development
   4—Homing devices
   5—Altimetry
   6—Flight-path computers
   7—Survivor location techniques
   8—GCI landing systems

7 **AIRCRAFT INSTALLATIONS**

20 **NUCLEAR PHYSICS AND NUCLEAR CHEMISTRY**

1 **ATOMIC STRUCTURE**

2 **NUCLEAR REACTIONS**

1 **COSMIC RADIATION**

3 **RADIOACTIVITY**
1. Atomic radiation effects on materials and components

4 **ISOTOPE SEPARATION**

5 **REACTORS AND PARTICLE ACCELERATORS**

6 **HEALTH PHYSICS**

7 **MILITARY APPLICATIONS**

8 **ELECTROMAGNETIC RADIATION FROM NUCLEAR EXPLOSIONS (IBDA)**

21 **NUCLEAR PROPULSION**

1 **ACCESSORIES**

2 **COMPONENTS**

3 **CONTROL**

4 **COOLING**

5 **DESIGN**

6 **INSTALLATION**

7 **OPERATIONS**

8 **PERFORMANCE**

9 **SHIELDING**

10 **TESTING**

22 **ORDNANCE**

1 **AMMUNITION AND EXPLOSIVES**
1. Solid propellant
2. Liquid propellant

2 **ARMOR**

4 **BALLISTICS**
1. Interior

(Continued on page 362)

RESEARCH AND DEVELOPMENT SOURCE INFORMATION

NAME OF CONTRACTOR	STREET ADDRESS	CITY AND STATE

NAME OF PERSON TO CONTACT AT HOME OFFICE	TITLE

TYPE OF ORGANIZATION ☐ CORPORATION ☐ PROPRIETOR ☐ PROFIT ☐ NON-PROFIT ☐ PARTNERSHIP	STATE IN WHICH INCORPORATED

PARENT ORGANIZATION OR SUBSIDIARIES	NUMBER OF EMPLOYEES	
	TOTAL	RESEARCH SCIENTISTS
	DEVELOPMENT ENGINEERS	OTHER TECH PERSONNEL

NAME OF NEAREST REPRESENTATIVE	STREET ADDRESS, CITY AND STATE	TELEPHONE NUMBER

Show below all categories listed in ***List of ARDC Technical Fields of Interest*** in which you have experience and in which you desire to participate in the Air Force Research and Development Program, indicating the appropriate information in the four columns.

If no present or past experience, show Interest In and Present Capability For a given field by entering I in column D.

Under each section listing, cite description or examples of your work with a few key words or phrases. ***Please Be Specific.*** If you do not find a section directly applicable to your work, choose the section or sections that are closely related and list your type of work under these. If additional space is required, continue on a separate sheet.

FIELD OF INTEREST *(Identify by Number and Title)* A	PRIME OR SUB CONTRACTORS *(Show P or S)* B	AIR FORCE, ARMY, NAVY OR OTHER CONTRACT *(Show AF, A N or O)* C	PRIMARY OR SECONDARY INTEREST *(Show P or S)* D	RESEARCH DEVELOPMENT OR PRODUCTION *(Show R, D, or P)* E
TITLE				

Div Sec

- 2. Exterior
- 3. Terminal

5 **BOMBS**
- 1. Bomb scoring and control

6 **EXPLOSIONS AND BLAST EFFECTS**
7 **FIRE CONTROL AND BOMBING SYSTEMS**
8 **GUNS**
9 **MOUNTS AND TURRETS**
10 **PROXIMITY FUSES**
11 **ROCKETS AND LAUNCHERS**

23 **PERSONNEL AND TRAINING**

1 **PERSONNEL PROCUREMENT AND ADMINISTRATION**
2 **INDUSTRIAL RELATIONS**
3 **WAGES, SALARIES AND BENEFITS**
4 **EDUCATIONAL AND VOCATIONAL TRAINING**
5 **MILITARY TRAINING AND INDOCTRINATION**
- 1. Selection, classification, assignment
- 2. Training operator personnel
- 3. Training maintenance personnel
- 4. Personnel and training requirements for future weapon systems

24 **PHOTOGRAPHY AND OTHER REPRODUCTION PROCESSES**

1 **CAMERAS**
2 **PHOTOGRAPHIC PROCESSES, TECHNIQUES, AND EQUIPMENT**
3 **MISCELLANEOUS REPRODUCTION PROCESSES, TECHNIQUES, AND EQUIPMENT**

25 **PHYSICS**

1 **ACOUSTICS**
2 **CRYSTALLOGRAPHY**
3 **ELECTRICITY AND MAGNETISM**
- 1. Atmospheric electricity

4 **OPTICS**
5 **QUANTUM MECHANICS**
6 **SOLID STATE PHYSICS**
- 1. Materials
- 2. Physical Metallurgy and Radio Chemistry
- 3. Conductor Theory: Studies of Electron Conduction Phenomena in Semiconductor's advanced dielectrical studies
- 4. Transistor development and operation
- 5. Microtronic circuitry, techniques, etc.
- 6. Magnetic techniques, theory, design
- 7. Cryostat studies
- 8. Spectra and Molecular theory
- 9. Thermodynamics
- 10. Electronic optics
- 11. Relativity

26 **PRODUCTION AND MANAGEMENT**

Div Sec

1 **FABRICATION**
2 **MANAGEMENT, ACCOUNTING, AND PUBLIC RELATIONS**
3 **PLANT DESIGN AND PRODUCTION PLANNING**
4 **QUALITY CONTROL**
5 **TOOLING**

27 **PROPULSION SYSTEMS**

1 **RECIPROCATING (INTERNAL COMBUSTION)**
2 **GAS TURBINE AND JET**
3 **ROCKETS**
4 **STEAM**

28 **PSYCHOLOGY AND HUMAN ENGINEERING**

1 **EXPERIMENTAL PSYCHOLOGY**
- 1. Human engineering

2 **INDUSTRIAL PSYCHOLOGY**
3 **PHYSIOLOGICAL PSYCHOLOGY**
4 **PSYCHOMETRICS**
5 **SOCIAL PSYCHOLOGY**

29 **QUARTERMASTER EQUIPMENT**

1 **CLEANING AND SANITATION EQUIPMENT**
2 **FOOD AND CONTAINERS**
3 **FURNISHINGS**
4 **KITCHEN EQUIPMENT**
5 **PERSONAL EQUIPMENT**
6 **PROTECTIVE EQUIPMENT**

30 **RESEARCH AND RESEARCH EQUIPMENT**

1 **ADMINISTRATION AND PROGRAMS**
- 1. Technical writing
  - 1—Technical reports
  - 2—Technical manuals
  - 3—Parts lists
  - 4—Specifications
  - 5—Maintenance and instruction handbooks
  - 6—Graphical representation
  - 7—Engineering standards

2 **COMPUTERS**
- 1. Analog
- 2. Digital
- 3. Data reduction—processing
- 4. Theoretical studies
- 5. Computing mechanisms
- 6. Information storage
- 7. Data presentation

3 **INSTRUMENTATION**
- 1. Trajectory computers and recorders
- 2. Tracking and target analysis
- 3. Timing and firing systems
- 4. Telemetry receiving
- 5. Data storage
- 6. Data separation and presentation
- 7. Optics

4 **LABORATORIES AND TEST FACILITIES**
- 1. Power sources—engine generators—gasoline, diesel, atomic
- 2. Test equipment
  - 1—Audio
  - 2—Microwave
  - 3—MTI test equipment
  - 4—Fault indicators
  - 5—Reliability devices
  - 6—RF plumbing
- 3. Display equipment
  - 1—Optical
  - 2—Electro-mechanical
  - 3—Animated
- 5 **METHODS AND TECHNIQUES**
- 1. Environment test facilities
- 6 **WIND AND WATER TUNNELS**

31 **SHIPS AND MARINE EQUIPMENT**

1 **DAMAGE CONTROL**
2 **MINE COUNTERMEASURES**
3 **MISCELLANEOUS EQUIPMENT**
4 **NAVAL ARCHITECTURE—SUBMARINES**
5 **NAVAL ARCHITECTURE—SURFACE SHIPS**
6 **SALVAGE**
7 **TORPEDO COUNTERMEASURES**
8 **VULNERABILITY STUDIES**

32 **SOCIAL SCIENCES**

1 **AGRICULTURE**
2 **ANTHROPOLOGY**
3 **DOCUMENTATION AND LIBRARY SCIENCE**
4 **ECONOMICS**
5 **HISTORY**
6 **LAW**
7 **PHILOSOPHY**
8 **POLITICAL SCIENCES**
9 **SOCIOLOGY**
10 **FINE AND DECORATIVE ARTS**
11 **LANGUAGES AND LITERATURE**
12 **MUSIC AND DRAMA**
13 **RELIGION**
14 **INTER-INDIVIDUAL AND INTER-GROUP RELATIONS**
- 1. Organizational effectiveness
- 2. Survival—social and psychological aspects
- 3. Efficiency, morals, job satisfaction
- 4. Administrative actions aimed at improvement
- 5. Resistance to interrogation
- 6. Relationship between Air Force and civilian population
- 7. Understanding characteristics of populations of foreign countries

33 **TRANSPORTATION**

1 **AIR TRANSPORTATION**
2 **HIGHWAY TRANSPORTATION**
3 **RAIL TRANSPORTATION**
4 **WATER TRANSPORTATION**

SUPPLEMENTAL SOURCE INFORMATION

In addition to completing the information requested on the opposite side, supply on a separate sheet of paper the information indicated in the following outline. If this information is included in your company brochure, then only the brochure need be submitted:

A. PERSONNEL

1. Names and brief biographical sketches of each of leading research and development personnel who might be principal investigators for an Air Force research and development contract.
- **a. Educational background.**
- **b. Work history.**
- **c. Books or papers published.**
- **d. Patents.**
- **e. Current fields of activity.**

B. FACILITIES

A brief description of laboratory equipment and other facilities pertainent to research and development activities. Indicate whether your facilities have been inspected or examined by Air Procurement District, Development Field Office, or other Air Force personnel concerned with evaluation for research and development purposes.

C. EXPERIENCE

Detailed information on your work in the fields checked on the reverse side which you feel should be included. This is important, particularly on current projects.
Return the 220 Service forms to appropriate ARDC Center and Hq.

NOTE: It is suggested that you keep appropriate ARDC agency advised of current capabilities of your organization as changes occur. Contractors may duplicate this form.

ADDRESS CORRESPONDENCE TO:

Commander
Air Research and Development Command
P. O. Box 1395
Baltimore 3, Maryland
Attn: RDSKMS

OR

Commander
..... Center
.....Air Force Base
.....
Attn. Contractor Relations and Sources Branch

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Find the key number as listed at the bottom of the advertisement. Circle key number on card. Mail card immediately.

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RESEARCH & DEVELOPMENT ISSUE
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346	347	348	349	350										

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- Production ☐
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- Design ☐
- Maintenance or Overhaul ☐
- Purchasing ☐
- Other ☐

YOUR BUSINESS

- MANUFACTURING
  - Aircraft ☐ Engines ☐
  - Components ☐
- AIR TRANSPORT ☐
- MILITARY PERSONNEL ☐
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- BUSINESS AIRCRAFT OPERATOR ☐
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- Production ☐
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- Design ☐
- Maintenance or Overhaul ☐
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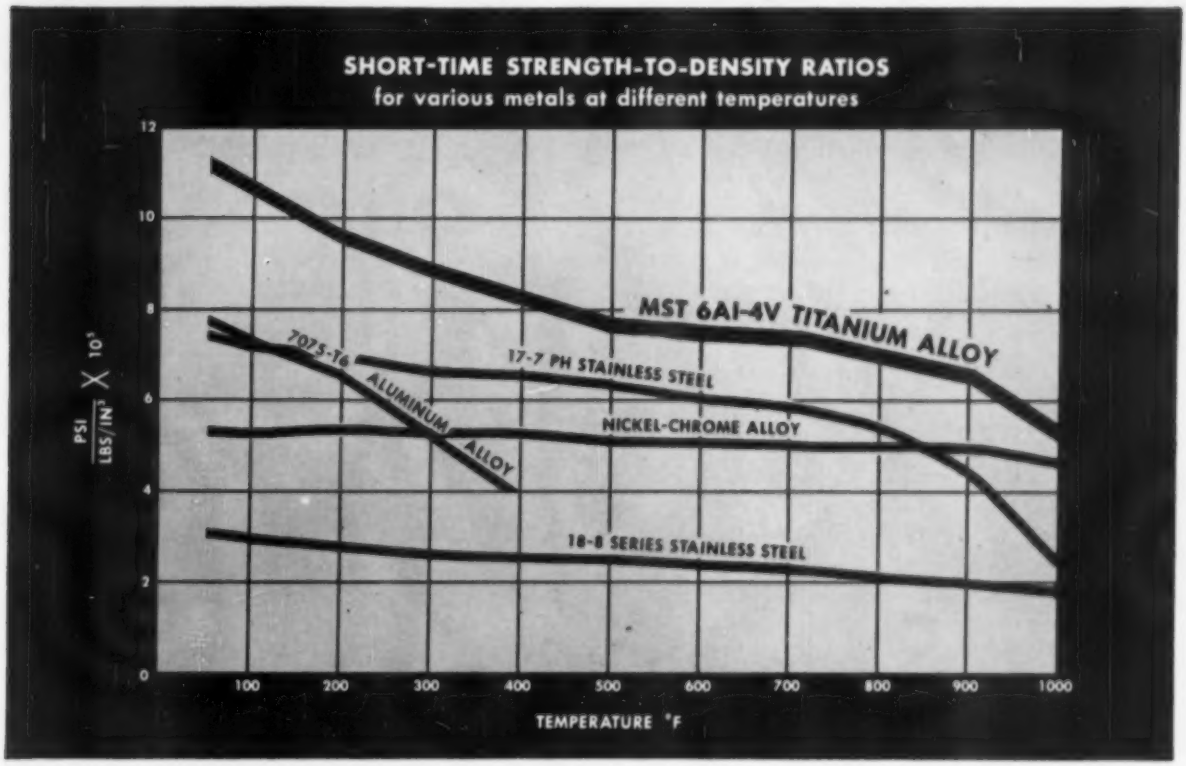
- Other ☐

YOUR BUSINESS

- MANUFACTURING
  - Aircraft ☐ Engines ☐
  - Components ☐
- AIR TRANSPORT ☐
- MILITARY PERSONNEL ☐
- GOV'MT. PERSONNEL ☐
- BUSINESS AIRCRAFT OPERATOR ☐
- AIRPORT OR SERVICE OPERATIONS ☐

Progress with **TITANIUM**



TITANIUM ON TOP

in medium-high temperature range

Today's most popular titanium alloy, MST 6Al-4V, excels all other metals in strength to density ratio through 900°F. At room temperature, considering only strength, a part made of this alloy need have only 60% of the weight of the equivalent part in stainless steel.

Performance for extended times at elevated temperatures is likewise good. In typical creep tests, with 1% permanent deformation allowed, MST 6Al-4V alloy shows 100,000 psi allowable stress at 750°F for 1 hour; 77,000 psi at 100 hours; 65,000 psi at 1000 hours.

Meanwhile new alloys extending the elevated temperature usefulness of titanium—to as high as 1000°F—are now emerging from the laboratory into production.

Write Dept. B-6 for copy of "Titanium Alloy Properties"

SELECTION GUIDE TO MST ALLOYS

Typical Mechanical Properties of Annealed Titanium and its Alloys

	Form	Ultimate Tensile Strength, psi	Yield Strength, psi	Elongation %
COMMERCIALLY PURE TITANIUM				
MST Grade III	Sheet, Bar	70,000	50,000	28
(3 different strength levels)	Sheet, Bar	85,000	65,000	23
	Sheet, Bar	100,000	80,000	20
TITANIUM ALLOYS				
MST 6Al-4V				
Annealed	Bar	140,000	130,000	15
Age hardened (1)	Bar	165,000	155,000	12
Age hardened (2)	Bar	160,000	155,000	10
Annealed	Sheet	140,000	125,000	12
MST 3Al-5Cr	Bar	155,000	145,000	13
MST 4Al-4Mn	Bar	150,000	140,000	14
MST 8 Mn	Sheet	137,000	125,000	16

(1) 1650°F—1 hour—WQ; 1100°F—2 hours—AC
(2) 1700°F—1 hour—WQ; 1000°F—8 hours—AC

WQ—Water Quench
AC—Air Cool

* Values for 1" on bar and 2" on sheet

MALLORY Ti SHARON

MALLORY-SHARON TITANIUM CORPORATION · NILES, OHIO

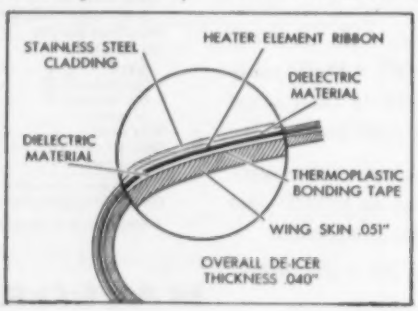
Producers of titanium and titanium alloy sheet, strip, plate, rod, bar, billets

Stainless steel De-Icers for Boeing KC-135 are lightweight, hail resistant

Boeing engineers wanted a dependable, lightweight system for heating the leading edge of the KC-135's giant stabilizer. Piping bleed air from the engines would have required heavy ductwork. Installing a blower in the tail would have added even more weight and taken up valuable space as well.

A new stainless steel De-Icer developed by B.F.Goodrich Aviation Products solved the problem of weight and space. In addition, the new De-Icer resists abrasion and erosion from rain and hail.

The new lightweight, metal-clad De-Icer (right) has ribbon-type electrical heating elements sandwiched between layers of resin-impregnated glass fabric, topped by an exterior skin of stainless steel. Pre-shaped to fit the contour of the 35 foot leading edge, the De-Icers are installed in 6 sections, attached with an adhesive bond.



In addition to stainless steel, these new De-Icers can be clad with other metals of various thicknesses and designed with power densities to meet specific requirements.

B.F.Goodrich has been solving problems in aviation de-icing for over 26 years. Take advantage of this leadership by letting B.F.Goodrich Aviation Products' engineers recommend the right system for your application.

B.F.Goodrich Aviation Products

a division of The B. F. Goodrich Company, Akron, Ohio

Tires • Wheels • Brakes • De-Icers • Inflatable seals • Fuel cells • Heated Rubber • Pressure Sealing Zippers • Rivnuts • Avtrim • Adhesives • Hose and rubber accessories

Circle Number 165 on Reader-Service Card

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(Note: Sponsoring agency is indicated by initials following company name.)

A

A C F Electronic Div., 800 N. Pitt St., Alexandria, Va., USAF.
A C F Industries, 299 State Hgwy, Paramus, N. J., USAF.
A R D E Associates, Newark, N. J., USAF.
Abrams Instrument Corp., 600-62 E. Shiawassee St., Lansing, Mich., USAF.
Abrasive Shot Co., Springville, N. Y., USAF.
Accessory Products Co., 617 Putnam Dr., Whittier, Calif., USAF.
Ace Brill Motors Co., 62nd St., Woodland, Philadelphia, Pa., USAF.
Ace Engineer Mach., 3644 N. Lawrence, Philadelphia, Pa., USAF.
Acme Aluminum Alloys Co., 215 Fundlay St., Dayton, Ohio, USAF.
Acme Electronics Co., 74 Willoughby St., Brooklyn, N. Y., USAF.
Acme Industries Co., 1425 Erie Blvd., Syracuse, N. Y., USAF.
Acoustic Research, Inc., 25 Thorndyke St., Cambridge, Mass., USAF.
Acton Laboratory, 533 Main St., Acton, Mass., USAF.
Acushnet Process Co., Belleville Ave., N. Bedford, Mass., USAF
Adair, J R. & Son, Orange St., Defuniake, Fla., USAF.
Adams Shoe Co., Adamsdale, Pa., USAF.
Adamson United Co., 730 Carroll St., Akron, Ohio, USAF.
Address Multi Corp., 1200 Babbit Rd., Cleveland, Ohio, USAF.
Adenstedt, Heinrich, Fairfield, Conn., USAF.
Adirondak Radio Supply Co., 32 Guy Park Ave., Amsterdam, N. Y., USAF.
Admiral Corp., 3800 Cortland St., Chicago, Ill., USAF.
Advance Electronics Laboratory, Inc., 451 Highland Ave., Passaic, N. J., USAF.
Advance Electronics Co., Rome, N. Y., USAF.
Aerial Machine & Tool Corp., 38-27 30th St., Long Island City, N. Y., USAF.
Aeromotor Co., 2500 Roosevelt Rd., Chicago, Ill., USAF.
Aero Development Corp., Box 949, Santa Monica, Calif., USAF.
Aero Equipment Corp., 303 S. East Ave., Jackson, Mich., USAF.
Aero Research Foundation, Soldiers Field, Cambridge, Mass., USAF.
Aero Service Corp., 236 E. Courtland St., Philadelphia, Pa., USAF.
Aero Supply Mfg. Co., 611 W. Main St., Carry, Pa., USAF.
Aero Test Equip. Co., 4316 Main St., Dallas, Tex., USAF.
Aeroaffiliated, Inc., Hicks Field, Ft. Worth, Tex., USAF.
Aerocal Engineers, 2627 Hollywood Way, Burbank, Calif., USAF.
Aeroflex Laboratory Corp., 34-08 Skillman Ave., Long Island City, N. Y., USAF.
Aerojet Engineering Corp., 6352 N. Irwindale Ave., Azusa, Calif., USAF, Navy.
Aerological Research, Pasadena, Calif., USAF.
Aeronautical Systems, Glendale, Calif., USAF.
Aeronca Mfg. Corp., 1712 Germantown Rd., Middletown, Ohio, USAF.
Aerophysics Corp., Box 657, Pacific Palisades, Calif., USAF.
Aeroprojects, Inc., 232 S. Matlack St., W. Chester, Pa., USAF.
Aeroquip Corp., 303 S. East Ave., Jackson, Mich., USAF.
Aerosonic Instr. Co., 3702 Lonsdale Ave., Cincinnati, Ohio, USAF.
Aerotec Corp., Comly Ave., Greenwich, Conn., USAF.
Aerovox Corp., 740 Belleville Ave., N. Bedford, Mass., USAF.
Affiliated Gas, 17877 St. Clair St., Cleveland, Ohio, USAF.
Air Associates, Inc., 60 Industrial Ave., Teterboro, N. J., USAF.
Air Cargo Equip. Co., 11252 Penrose Ave., Sun Valley, Calif., USAF.
Air Conditioned, Charleston, W. Va., USAF.
Air Cruisers, Inc., Monmouth County Airport, Belmar, N. J., USAF.
Air Lock, Inc., 108 Gulf St., Milford, Conn., USAF.
Air Logistics Corp., 3600 E. Foothill Blvd., Pasadena, Calif., USAF.
Air Products, Inc., Box 538, Allentown, Pa., USAF.
Air Reduction Sales Co., 60 E. 42nd St., New York, N. Y., USAF.
Airborne Accessories Corp., 25 Montgomery St., Hillside, N. J., USAF.
Airborne Inst. Laboratory, 160 Old Country Rd., Mineola, N. Y., USAF.
Aircraft Armaments, Inc., 4003 Seven Mile Lane, Baltimore, Md., USAF.
Aircraft Equip. Testing Co., 1812 Fleet St., Baltimore, Md., USAF.
Aircraft Radio Corp., 708 Main St., Boonton, N. J., USAF.
Aircraft Tools, Inc., 9030 Ballanca Ave., Los Angeles, Calif., USAF.
Airpax Products Co., Middle River, Baltimore, Md., USAF.
Airtron, Inc., 1101 W. Elizabeth Ave., Linden, N. J., USAF.
Ajax Electrothermic Co., Ajax Park, Trenton, N. J., USAF.
Akeley Camera, Inc., 175 Varick St., New York, N. Y., USAF.
Alabama Polytechnic Institute, Auburn, Ala., USAF.
Alabama University, University, Ala., USAF, NACA.
Alamo Materials Co., Drawer 792, Alamogordo, N. M., USAF.
Alamo Sheet Metal Works, Box 1137, Alamogordo, N. M., USAF.
Alans Silk Screen Co., 35 S. St. Clair, Dayton, Ohio, USAF.
Alar Products Inc., 1071 Power Ave., Cleveland, Ohio, USAF.
Albuquerque Precision, 4509 Fourth St., N.W., Albuquerque, N. M., USAF.
Alden Electronic Equip. Co., Box 125, Westboro, Mass., USAF.
Alderson Research Laboratory, 10 E. 38th St., New York, N. Y., USAF.
Alford, Andrew, 299 Atlantic Ave., Boston, Mass., USAF.
Alfred Electronics Co., 897 Commercial St., Palo Alto, Calif., USAF.
Alfred University, Alfred, N. Y., USAF, Navy.
All American Aviation, 210 Greenhill Ave., Wilmington, Del., USAF.
All American Eng. Co., Dupont Airport, Wilmington, Del., USAF, Navy.
Allegheny Instr. Co., 1000 Oldtown Rd, Cumberland, Md., USAF.
Allegheny Ludlum Steel Corp., 2020 Oliver Bldg., Pittsburgh, Pa., USAF.
Allied Chemical Dye Corp., 61 Broadway, New York, N. Y., USAF.
Allied Control Co., 2 E. End Ave., New York, N. Y., USAF.
Allied Radio Corp., 100 N. Western, Chicago, Ill., USAF.
Allied Research, 43 Leon St., Boston, Mass., USAF.
Allis Chalmers Mfg. Co., 1943 McGraw St., Milwaukee, Wis., USAF.
Allstates Eng. Co., 25 N. Warren St., Trenton, N. J., USAF.
Altair, Inc., 50 McQuestion Pkwy, Mt Vernon, N. Y., USAF.
Aluminum Co. of America, 2210 Harvard Ave., Cleveland, Ohio, USAF.
Amerac, Inc., 116 Topsfield Rd., Wenham, Mass., USAF.
American Air Filter Co., 1824 Third St., Moline, Ill., USAF.
American Car and Foundry, Albuquerque, N. M., USAF.
American Chain Co., 601 Stephenson Bldg., Detroit, Mich., USAF.
American Chronscope Co., 316 W. First St., Mt. Vernon, N. Y., USAF.
American Cyanamid Co., 30 Rockefeller Plaza, New York, N. Y., USAF.
American Cystoscope, Inc., 1241 Lafayette Ave., New York, N. Y., USAF.
American Electric Supply Co., 1106 Commonwealth Ave., Boston, Mass., USAF.
American Electro Metal Corp., 320 Yonkers Ave., Yonkers, N. Y., USAF, Navy.
American Electronic Laboratories, Inc., 641 Arch St., Philadelphia, Pa., USAF.
American Finishing Co., Badley and McMillan Sts., Memphis, Tenn., USAF.
American Flexible Coupling Co., Erie, Pa., USAF.
American General Supply Co., 53 Worth St., New York, N. Y., USAF.
American Geographic Society, Broadway at 156th St., New York, N. Y., USAF.
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FILLING A NEED...

During the nineteenth century, the mechanics of fluids branched off the main stem of physical science. Physics concentrated on the elaboration of the structure of molecules and their components; the development of fluid mechanics was guided by the need for understanding the macroscopic phenomena associated with ships, turbines, airplanes, etc. The separation between these disciplines has been reflected in the organization of university departments for several generations, so that there is little contact between physics and fluid mechanics departments. This lack of contact has been reflected in our scientific graduates who typically have been trained in one or the other of these disciplines, but almost never in both.

Very suddenly, however, the country faced an important problem when we had to meet the challenge of rapidly creating an operable intercontinental ballistic missile. The re-entry of this missile into the earth's atmosphere was regarded as a very difficult problem; largely because here, for the first time, we faced a scientific problem involving the mechanics of a fluid closely coupled with important aspects of molecular physics. The Avco Research Laboratory was created to fill this need. Its senior scientific personnel were trained in classical aerodynamics, atomic physics, and physical chemistry, and saw in this interdisciplinary area a unique opportunity to broaden their background and to make creative contributions in a field in which the great advances are still to be made.

The laboratory has been successful in supplying vital information which only a year ago was generally held to be obtainable only in costly and time-consuming flight experiments. Our research success has resulted in a large development responsibility being entrusted to this company.

The interdisciplinary strength we have acquired will enable us to play a major role in such problems as the re-entry of manned vehicles into the atmosphere from satellite orbits, in the creation of a thermonuclear reactor, and in other fields involving the dynamics of high temperature gases.

Arthur Kantrowitz

Dr. Arthur Kantrowitz, Director
AVCO RESEARCH LABORATORY
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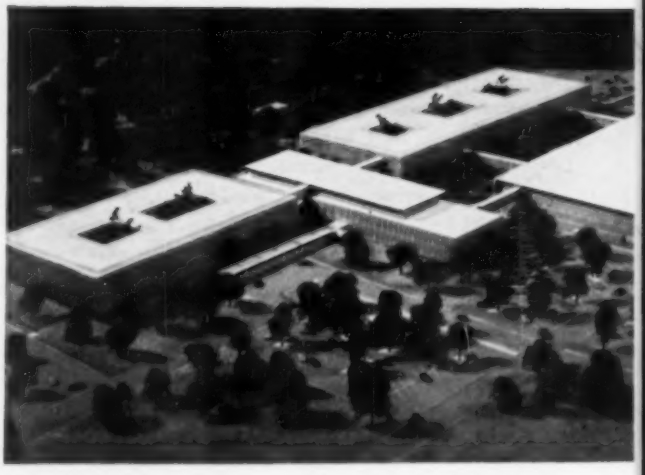

Pictured above is our new Research Center now under construction in Wilmington, Massachusetts. Scheduled for completion in early 1958, this ultra-modern laboratory will house the scientific and technical staff of the Avco Research and Advanced Development Division.

The Avco Research Laboratory at Everett, a unit of A.R.A.D., has a few openings for leading scientists who can help us expand our capabilities in:

Theoretical, Experimental and Solid State Physics
Physical Chemistry—Aerodynamics—Physical Electronics

There are other career opportunities for exceptionally qualified scientists and engineers in the Development Laboratory at Lawrence and the Electronics Laboratory at Boston, in such fields as:

Science:
Physics—Mathematics—Metallurgy—Thermodynamics—Aerodynamics

Engineering:
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The Patented Mark 4 Fully Automatic Lightweight Ejection Seat is designed and produced by the Martin-Baker Aircraft Company Limited.

Considerable ingenuity in design has resulted in a seat of remarkably low installed weight and compact construction. Tests have proved that the seat is capable of effecting safe escape at all speeds and altitudes within the range of modern aircraft.

Safe escape from ground level is practicable because of the high velocity of the long stroke Ejection Gun and the rapid deployment of the main parachute. At very high ejection speeds the opening of the main parachute is delayed by a patented automatic sensing mechanism which is sensitive to the rate of deceleration of the seat. The well proven time fired drogue gun, Duplex Drogue system and barostatic time release mechanism which have been so successful in earlier seats have been retained, though considerably lightened and improved in detail design.

Production of the seat has been preceded by extensive design and test programmes, ejections being carried out at all speeds and at altitudes ranging from ground level to more than 42,000 feet.

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Designing to total dynamic environment . . .
A NEW CONCEPT in shock and vibration protection
for missiles and jets

The total dynamic environment against which equipment must be protected in missiles and jets is so violent that protection by conventional unit isolators is impractical. Unit isolators built to meet the demands of this service would be relatively huge, yet there is no room for even admittedly inadequate present-day isolators.

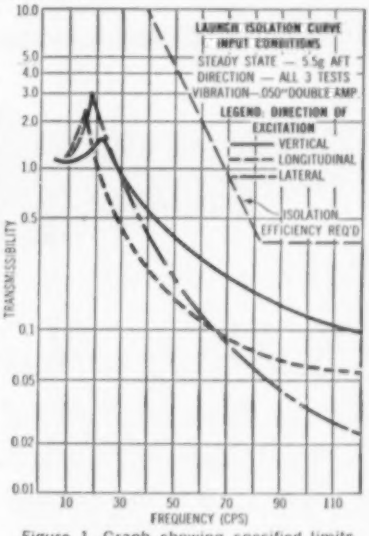


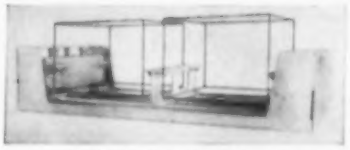
Figure 1. Graph showing specified limits of isolation efficiency during missile launching and the performance of distributed-element mounting system.

The total dynamic environment

Severe shock during launching, high g values of sustained acceleration with superimposed vibration, high-amplitude vibrations, and operation through all flight attitudes from horizontal to vertical — these are the elements of the dynamic environment met in currently operational missiles and detailed in the following specifications.

- Effective vibration isolation under steady-state acceleration of 6 g
- Shock transmissibility not over one for 15-g, 11-millisecond half-sine-wave shock, per Procedure I, MIL-E-5272A
- No snubber contact under high-amplitude low-frequency vibration input
- Low transmissibility at resonance
- Effective vibration isolation for all frequencies above 50 cycles per second
- Compliance with these requirements for every mounting position or attitude
- Provision of the required characteristics in an isolation system of minimum size and weight.

Obviously, MIL-spec isolators are inadequate to meet these stringent requirements.



A distributed system

A totally new design concept — a distributed-element isolation system — not only does the necessary job but provides substantial space savings as well. This is how it works. A number of small, single-degree-of-freedom, spring-and-friction-damper elements are so disposed about the mounted units that spring rates are equal for all directions of loading. This makes the isolation characteristics the same for every operating or installation position.

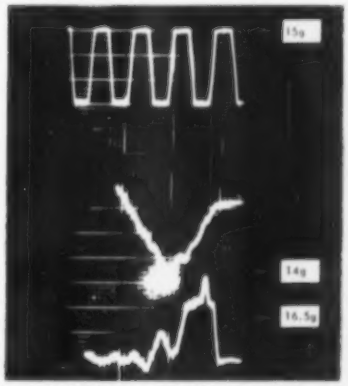


Figure 2. Oscillogram for shock test along vertical axis for an integral mounting system carrying two, six-pound electronic units. Upper trace: amplitude calibration at 60 cps. Middle trace: output from mockup of equipment. Lower trace: input to mounting assembly.

Matching the environment

With this new design concept, both the stiffness and the damping of the individual isolation elements can be selected so that the system is matched to the application. Thus it becomes feasible to provide greater shock protection in one plane, to design for different vibration inputs from different directions, or to provide whatever compensation is needed to suit the total dynamic environment. And because the separate elements can be located wherever space is available, this system minimizes space requirements.

A further advantage of this protection system is the ability to accommodate large vibration amplitudes without snubber contact. This is a result of the non-linear friction damping that can be set to limit the movement of the equipment under resonant conditions. This type of damping also allows efficient isolation of low-amplitude, high-frequency vibration because only slight damping occurs at the higher frequencies.

Additional design data

Ask for Report No. 602 giving detailed information on the specifications being met by Barry Integral Bases using the "distributed-element isolation" concept of characteristic selection.

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Barry's new Western Division, in Burbank, Cal., offers fast, on-the-spot design and prototype service, and production of special systems.

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New Cessna YH-41 delivers top performance

plus big maintenance savings to helicopter flying!

Cessna's all-new YH-41, recently purchased by the U. S. Army for its air arm, combines the latest in design and engineering advances to give operating and maintenance performance never before experienced in the helicopter field!

For example, the engine—mounted in the nose of the fuselage—makes installation and servicing easy—provides extra cargo or passenger space. Cessna has made the rotor assembly aerodynamically clean. Also, the drive system on the new YH-41 is a masterpiece of simplicity, has a minimum of parts—conveniently located for easy servicing.

Offering multi-utility uses, the 4-place YH-41, at 3,000 lbs. gross weight, can climb higher, faster than any other helicopter in its class—sea level to 10,000 ft. in less than 12 minutes! Its speed is the fastest in the light helicopter field.

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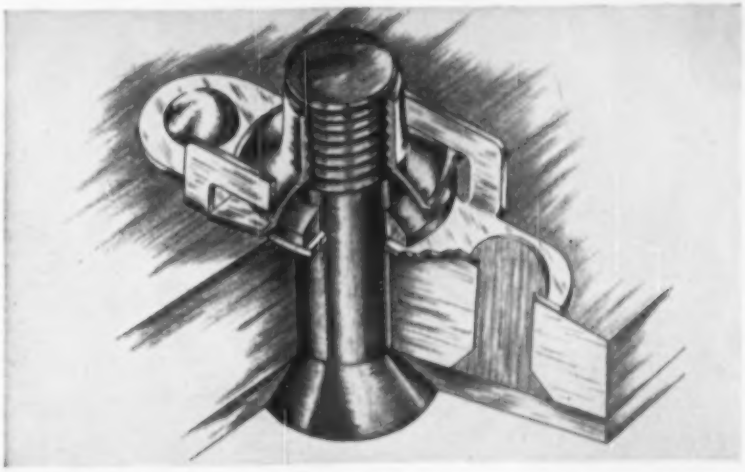
FASTENER PROBLEM



Lightweight floating anchor nut for bolting non-parallel surfaces

THE PROBLEM: Using large single forgings for aircraft bulkheads, wing center sections, spars and ribs offers manufacturers many advantages. It simplifies design and reduces milling costs, and it provides greater strength while reducing air frame weight. However, this type of construction also creates fastening problems. For example, attaching skins and components to these tapered forgings is difficult because the bolt head and seating surfaces are not parallel. Two methods are frequently used to make the fastening areas parallel. They are: 1) spot face machine the seating surfaces, 2) build up each bolt head or nut base with tapered shims. Because there are often hundreds of fastening points, both of these methods are excessively costly and time consuming.

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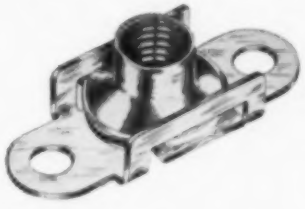

Type LHA3022 is made of carbon steel for use at temperatures up to 550°F. It meets AN-N-10 performance and MIL-N-25027 (ASG) twist- and push-out specifications. Like all Elastic Stop® nuts, it is vibration proof and reusable.

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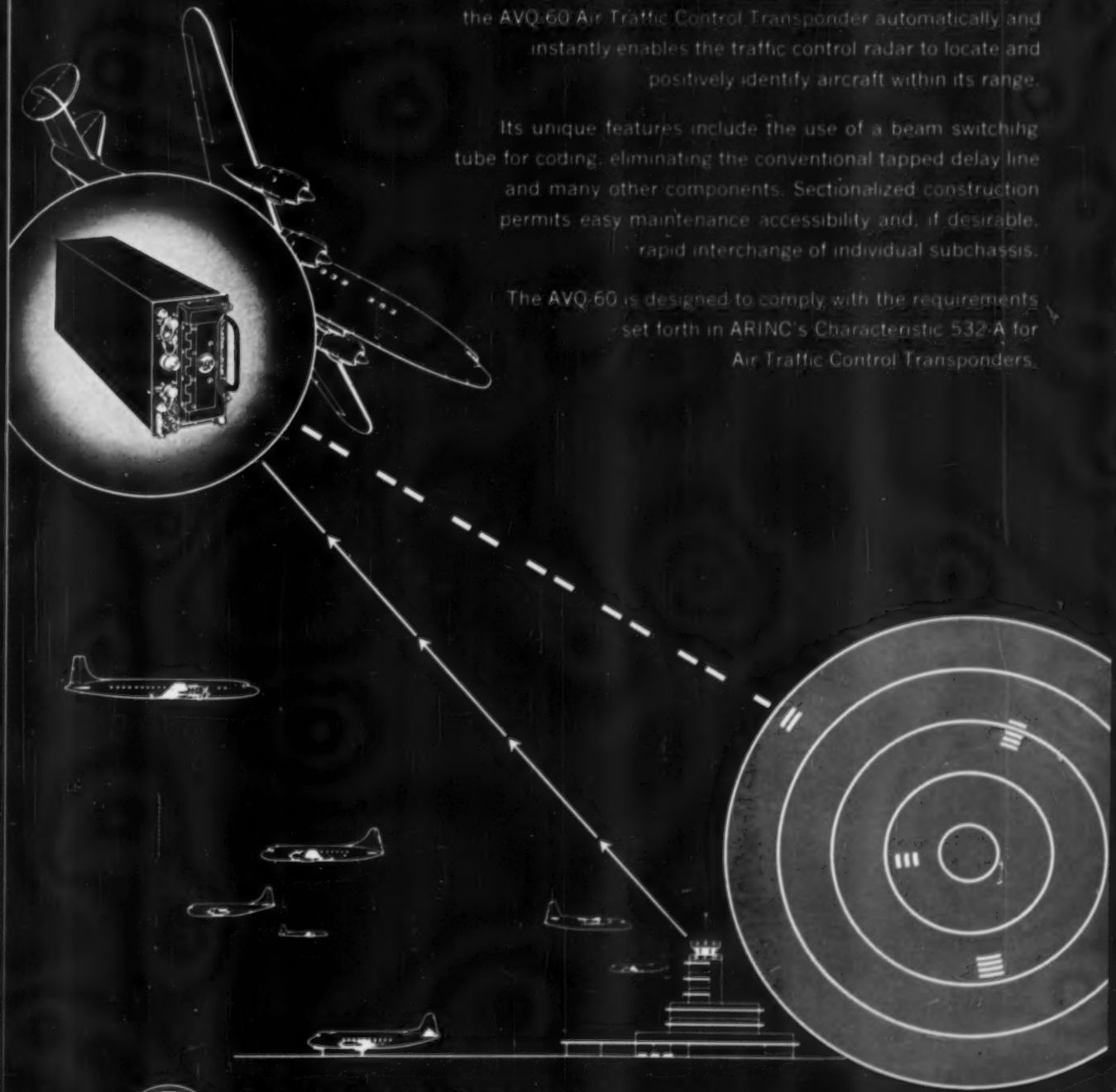

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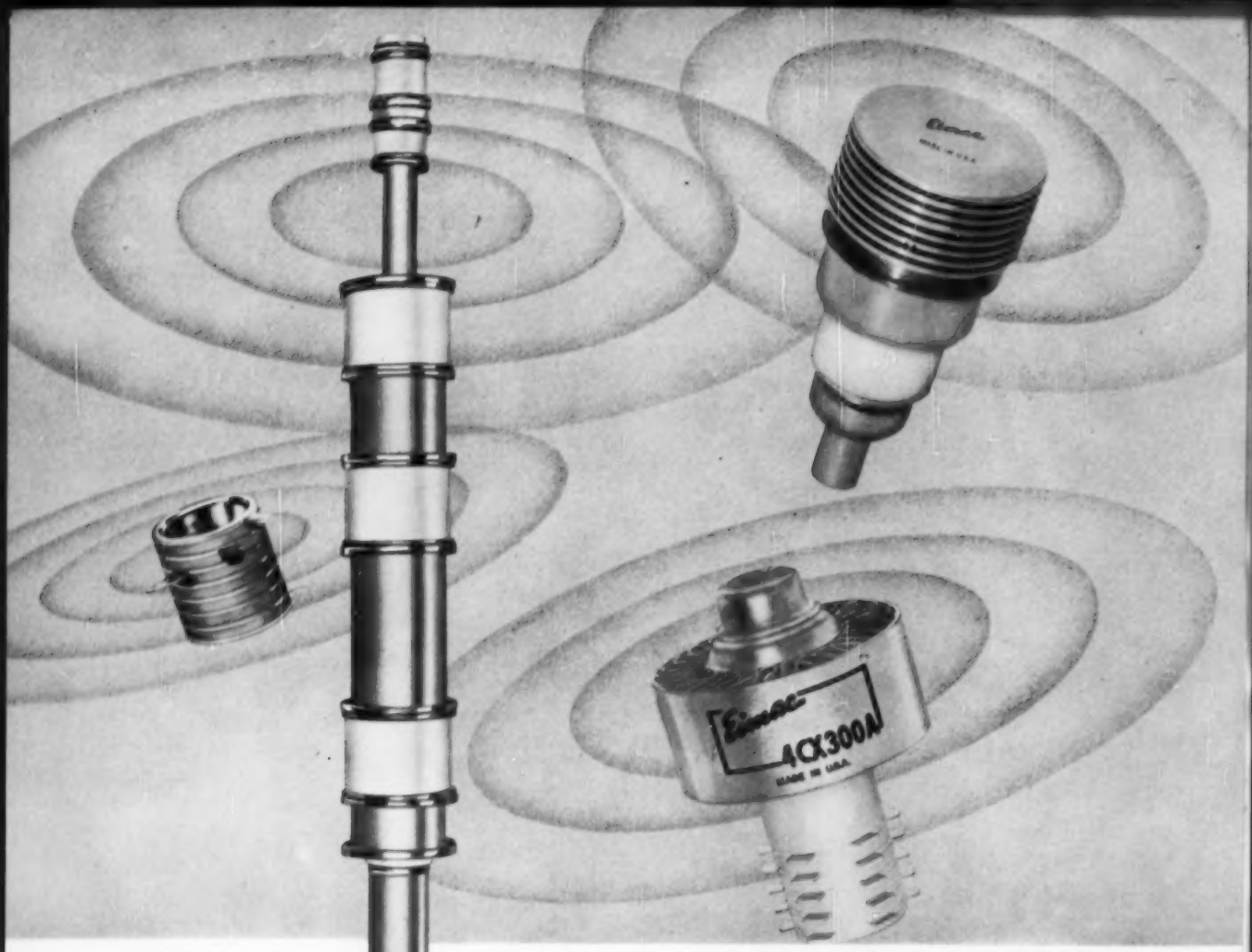

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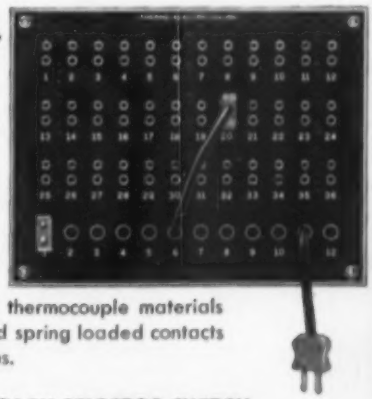
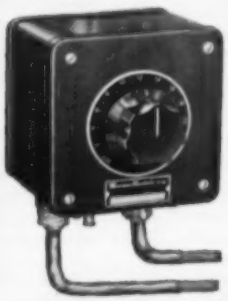


Provide great flexibility for transferring numerous thermocouples—ideal for patch panel use. Many compact shapes and sizes. Panel for 48 thermocouples and 16 pyrometers measures only 13¼ x 7⅞". Polarized plugs and jacks of standard thermocouple materials have long-wiping surfaces and spring loaded contacts for good electrical connections.



ROTARY SELECTOR SWITCH

For quick checking or switching of thermocouples or resistance bulbs. "Shorting-type" switches designed for flush panel or wall mounting. Contacts and wipers of same silver alloy. Three models have OFF to 6, 12 and 24 points.

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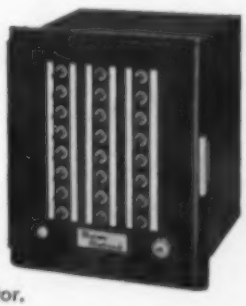

Provide a choice of connecting many sensing elements to one instrument or transferring sensing elements from one type of instrument to another. Locking or non-locking construction.

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For on-off checking of temperatures from many points or averaging any number of temperatures on one indicator.

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TECHNIQUES and DEVELOPMENTS in oscillographic recording

FROM

SANBORN

RECORDING METHOD USED IN SANBORN DIRECT WRITERS, AND A REVIEW OF THEORETICAL AND ACTUAL ERROR FACTORS

Figure 1 shows the basic scheme by which Sanborn oscillographic recording galvanometers produce graphic records of electrical signal values. If the rapid deflection action of the heated ribbon tip stylus is visualized when current flows in the coil, it can be seen that a straight line at right angles to the chart length is recorded on the chart, at the point where the chart is drawn over a knife edge. The trace, therefore, is a true rectangular co-ordinate graph.

Since this is essentially a process of expressing coil (or stylus) deflection *angles* in terms of *distances* on a chart, the trigonometry of the situation (Fig. 2) must be examined to ascertain the accuracy of the method. Initially, and when θ is small, the tangent and the angle are almost equal numerically. The expression $D = R \tan \theta$ can, therefore, be rewritten $D = R\theta$ (approx.). To the extent this latter expression is true, deflection distances (rather than deflection angles) are an accurate measure of signal values. But to determine the extent of error resulting from using this approximation, the following data have been calculated*, using a chart width of 25 mm either side of zero ("D" in Fig. 2) and effective stylus length of 100 mm ("R" in Fig. 2) in the series expansion for the tangent function. Error as a function of deflection then becomes:

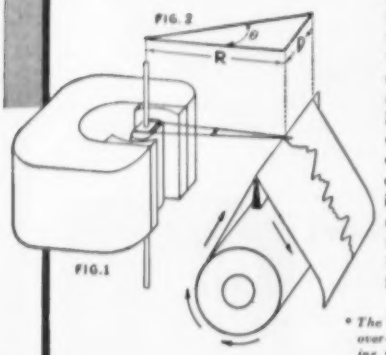

FIG. 1

D mms	Radians	Theoretical Error ϵ	Corrected Error δ	Corrected Error in mms
10	.10	.0033	0	0
15	.15	.0075	.004	.06
20	.20	.0133	.010	.20
25	.25	.0209	.018	.45

When the recording system is calibrated, that calibration is often made on the basis of a one centimeter deflection from the chart center, or by means of a two centimeter deflection starting one centimeter below chart center and finishing one centimeter above chart center. In either case the deflection at one centimeter from chart center is accepted as the standard, and, therefore, is without error. The foregoing table can therefore be corrected by subtracting .0033 from each of the error terms to show the error, δ, to be expected in actual use. The final column in the table shows this error in mms.

Since the active length of the stylus increases as θ increases, deflection D increases more rapidly than θ. All positive error terms in the series expansion bear this out, but the error terms would occur as predicted only if the galvanometer produced deflections exactly proportional to coil currents (that is, ideal spring properties in the torsion rods and uniformity of magnetic field). Pole tips in Sanborn galvanometers are proportioned so that in maximum deflections, galvanometer sensitivity *decreases* slightly, the compensation resulting in *actual* linearity better than that predicted in the table.

* *The mathematics involved here, as well as a discussion of fixed length stylii, design parameters affecting over-all galvanometer performance, etc., are contained in an article by Dr. Arthur Miller "Sanborn Recording Galvanometers", published in the May 1956 Sanborn RIGHT ANGLE. Copies are available on request.*

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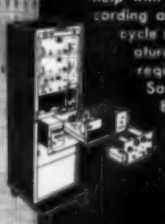

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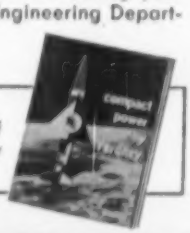

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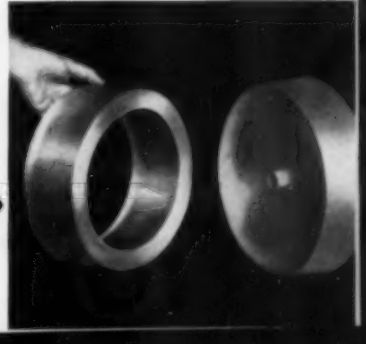

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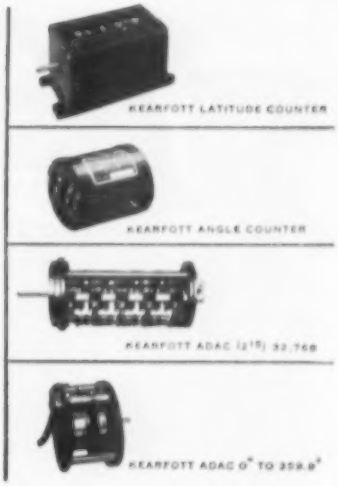

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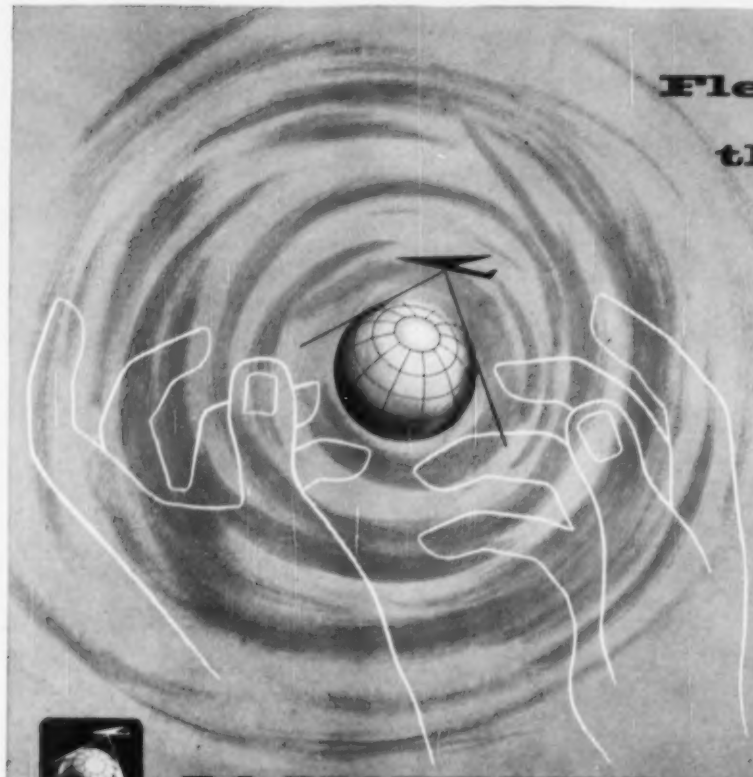

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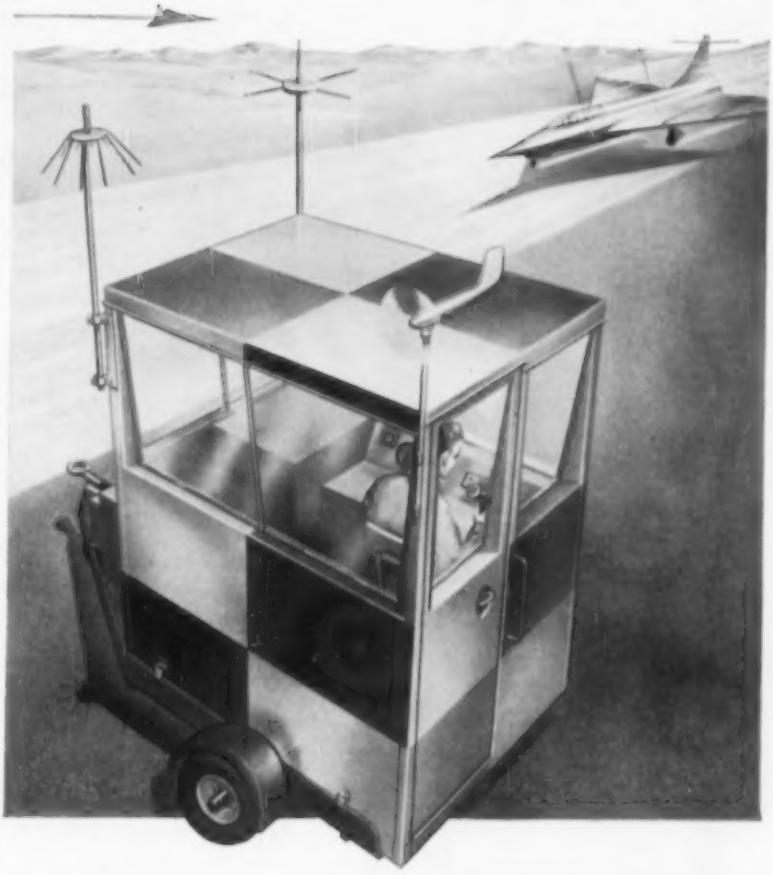

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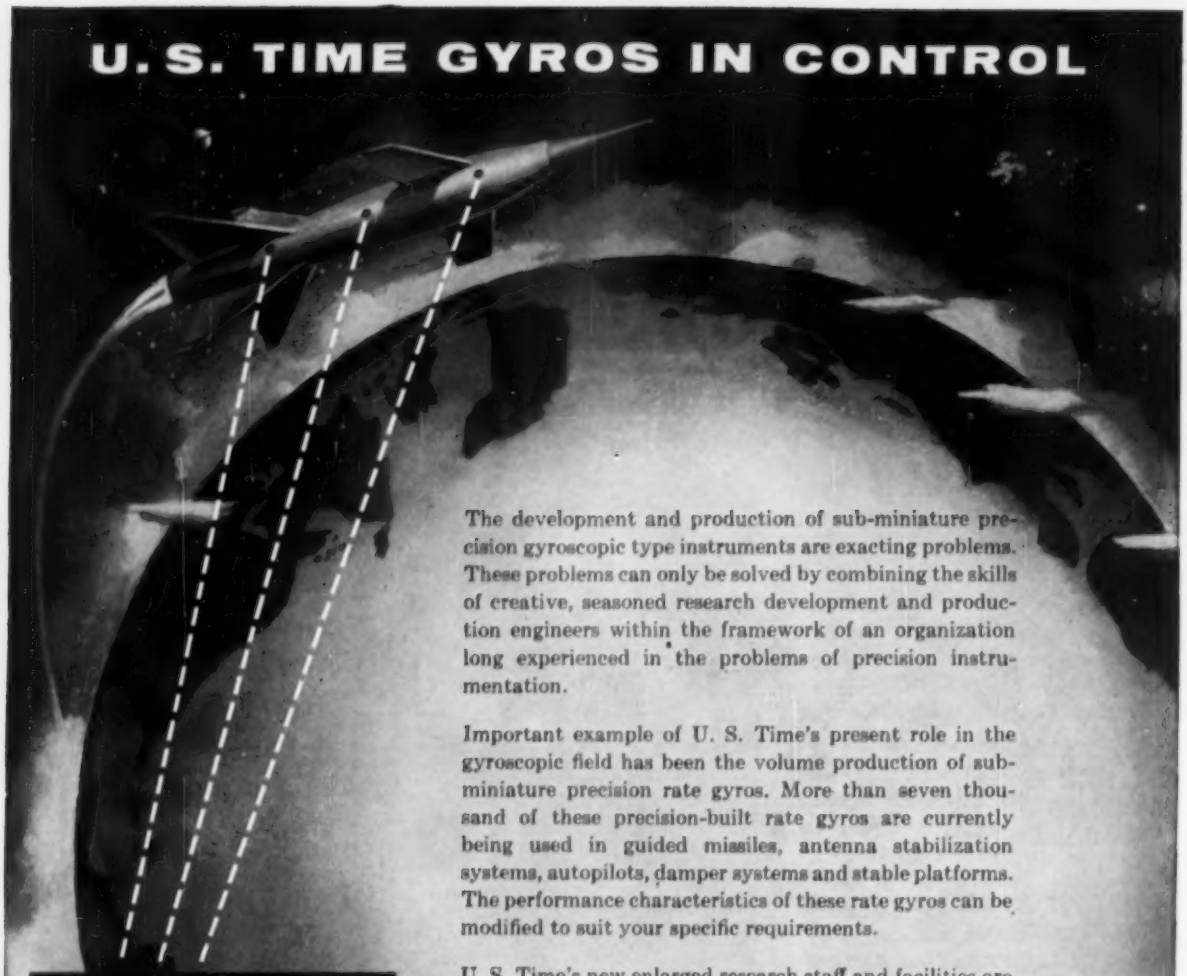

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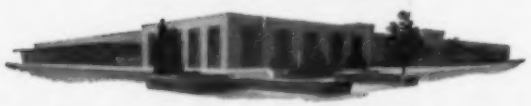

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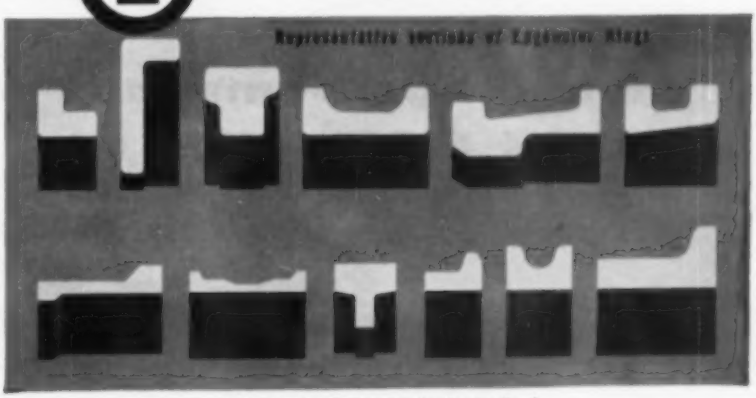

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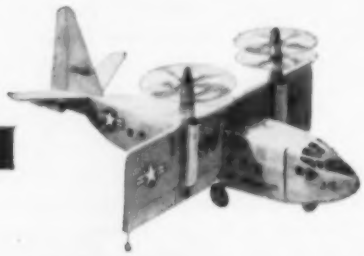

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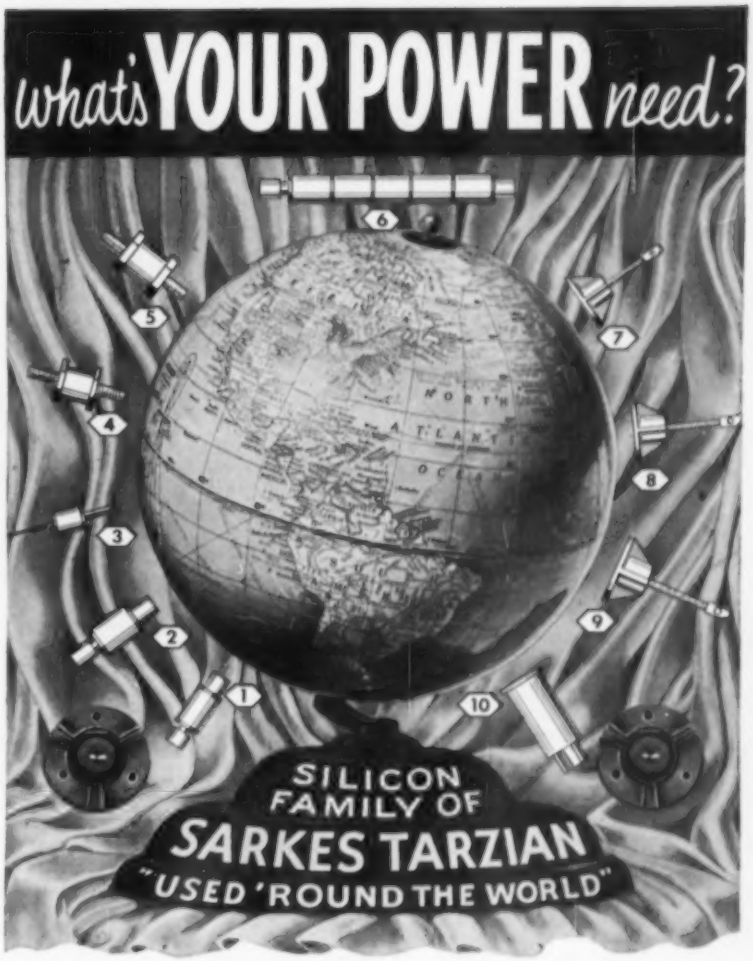

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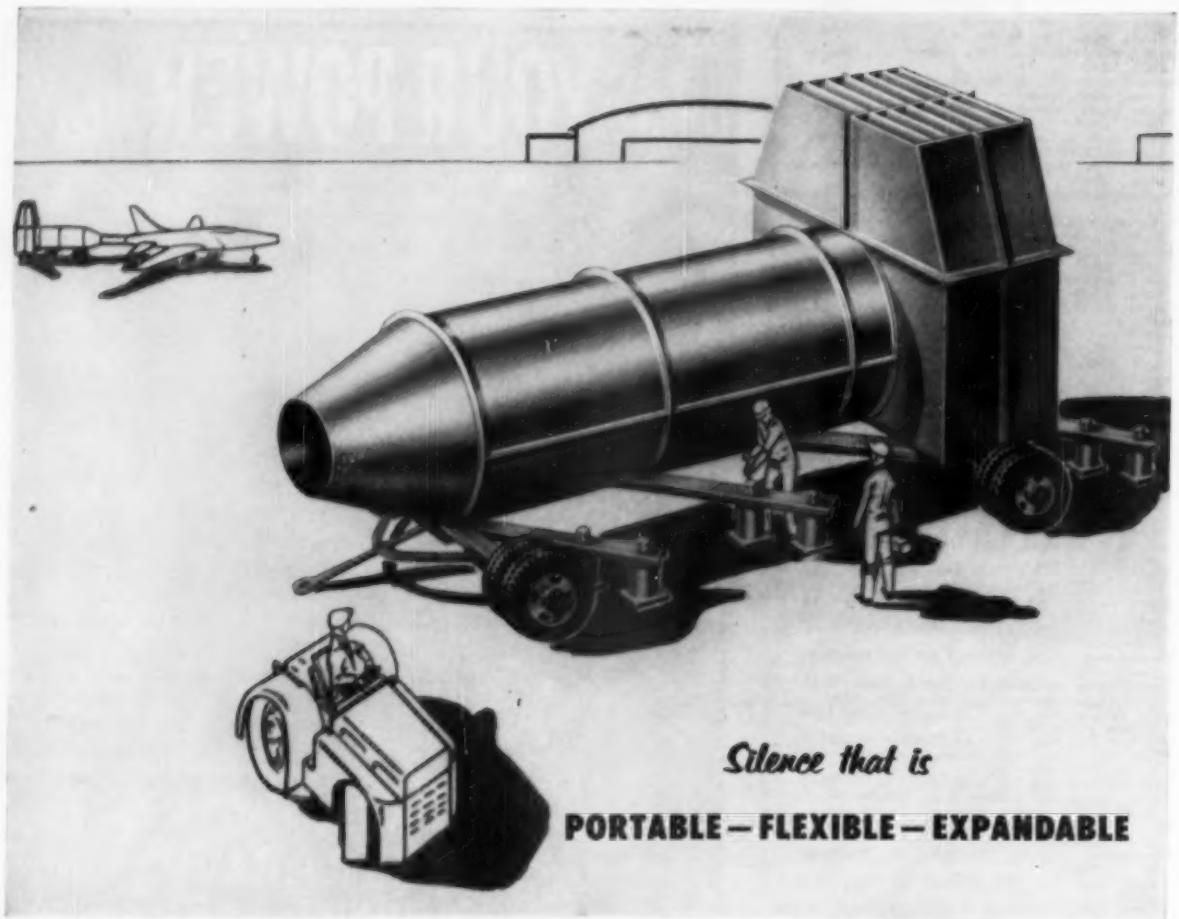

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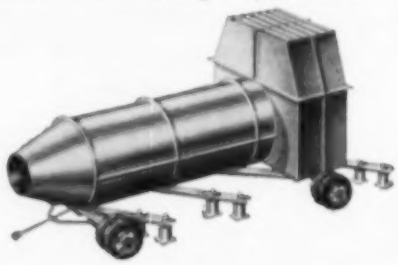

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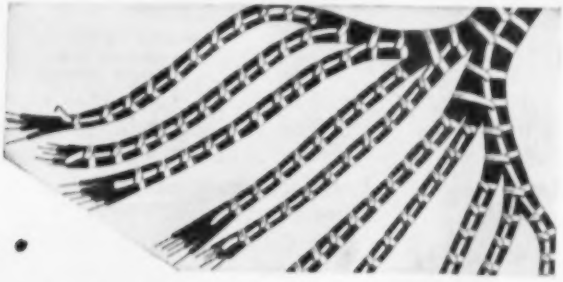

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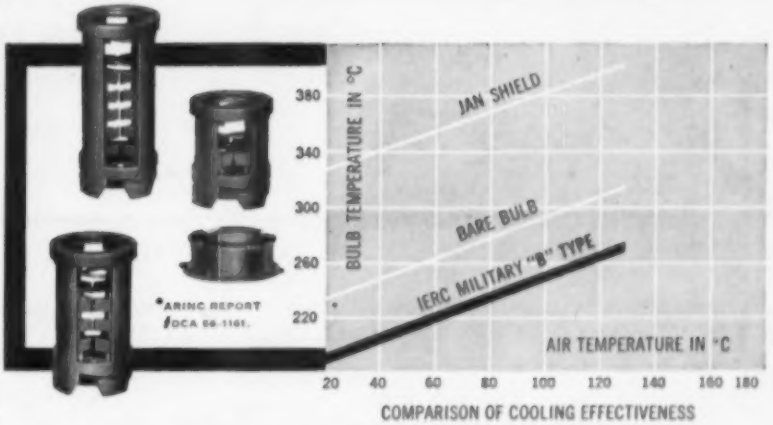

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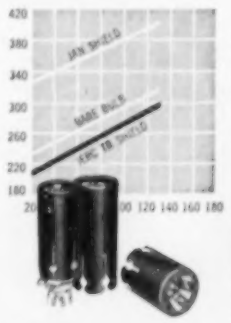

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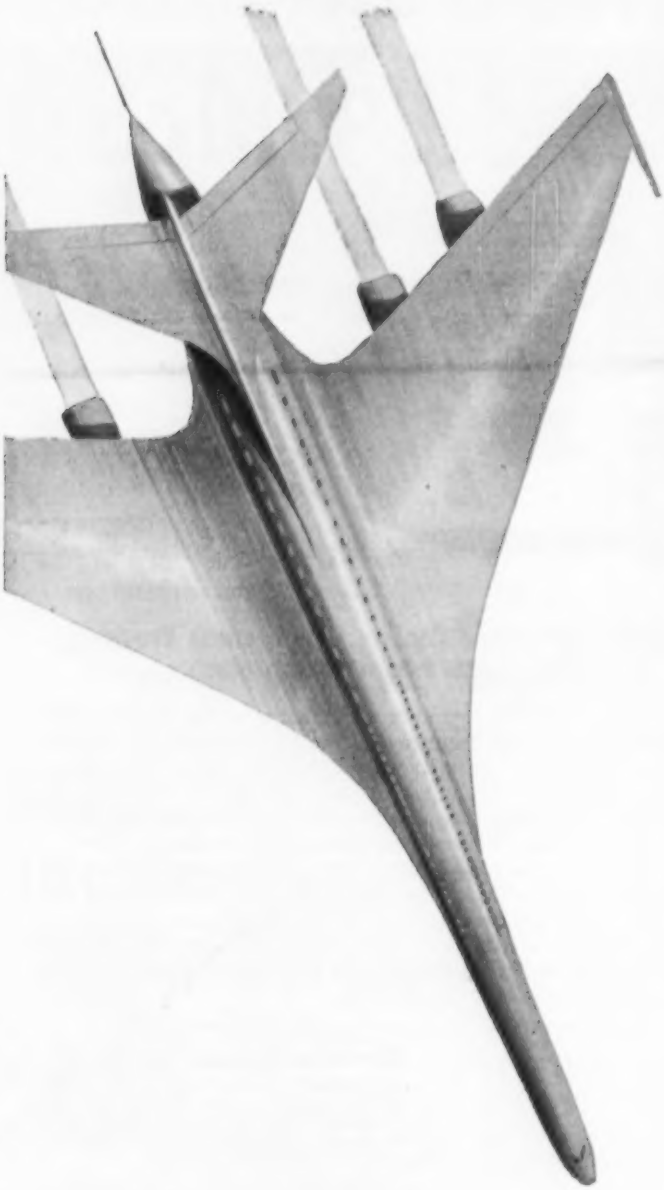

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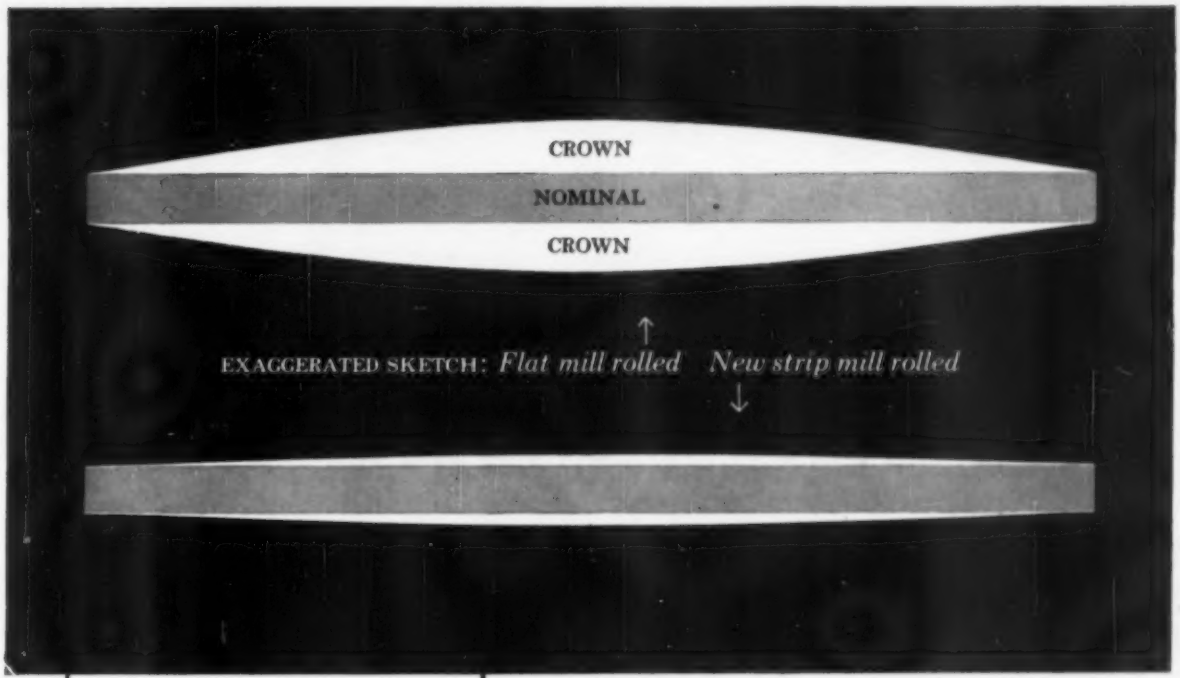
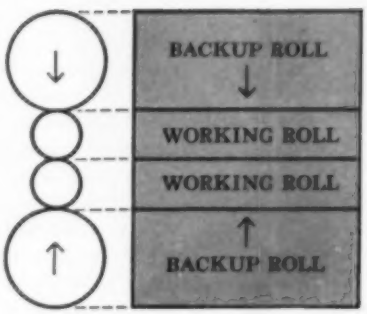
Weight slashed on wide sheet





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The present Rate of Descent Recording Device consists of three basic components, A Parabolic Antenna, an Electronics Assembly, and a Recorder Device. The total weight is less than five pounds and it occupies a space of 0.25 cubic feet. It can be operated by batteries or any other suitable power supply.

The Recorder, as it is now developed, is driven by a constant torque spring and can readily be made to operate upward to 25 or 30 minutes on one winding. A modification allows for an electric motor drive, where that may prove desirable. The Recorder furnishes an instantaneous graphic record of time versus distance for easy data reduction.

The entire system is currently designed to measure rate of change below 1000 feet which is considered ample altitude for experimental parachute tests. Further development is expected to allow for considerably greater distances, or altitudes.

The system is versatile in that it can be made to measure motion at unbelievable distances. It can be made to actuate a visual indicator or any voltage or pulse driven system, such as a telemetering transmitter for instance. It is also an excellent proximity device of extreme sensitivity, and could be modified to measure small changes of altitude as an aid to Pilots of Vertical Take-off aircraft.

For detailed information on specifications operating characteristics or applications, please phone or write C. E. Malsberger, Chief Electronics Engineer, at Frank Mayer Engineering Company, 6442 Santa Monica Boulevard, Los Angeles 38, California.

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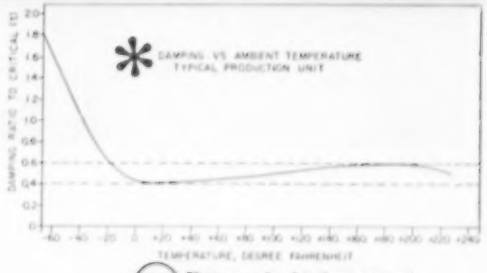

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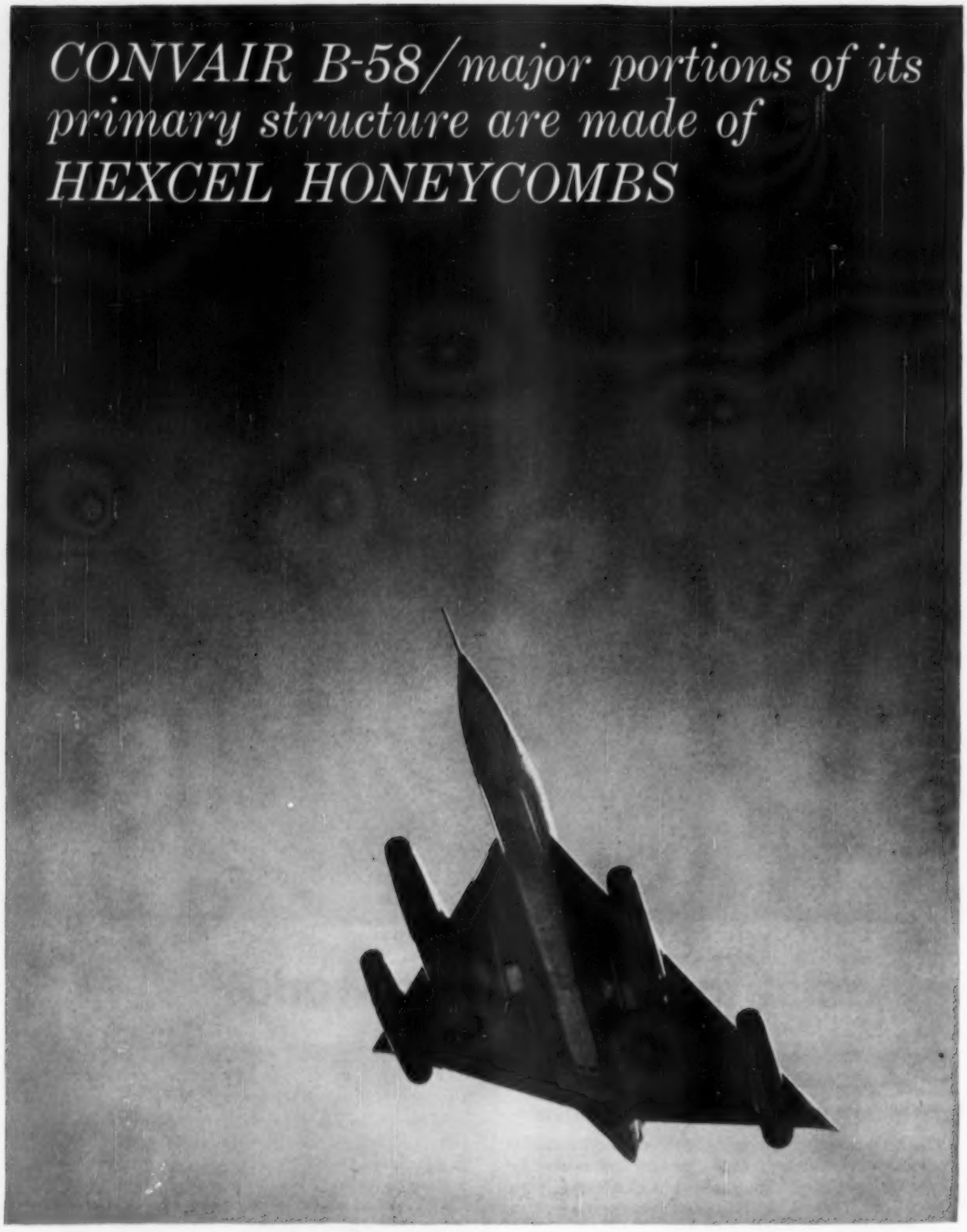

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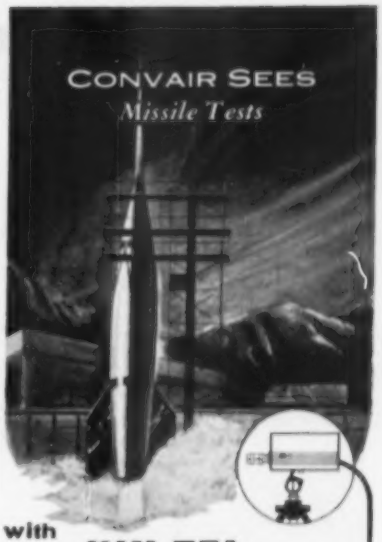

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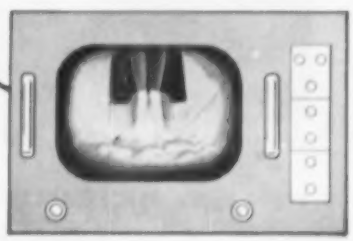

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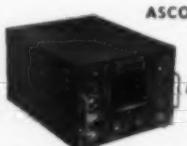

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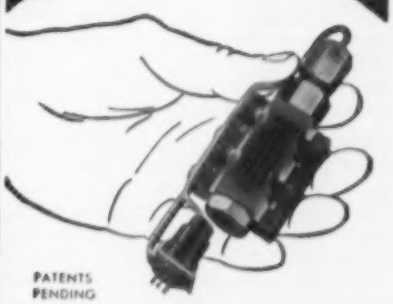
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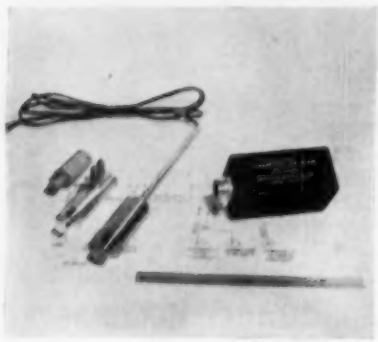

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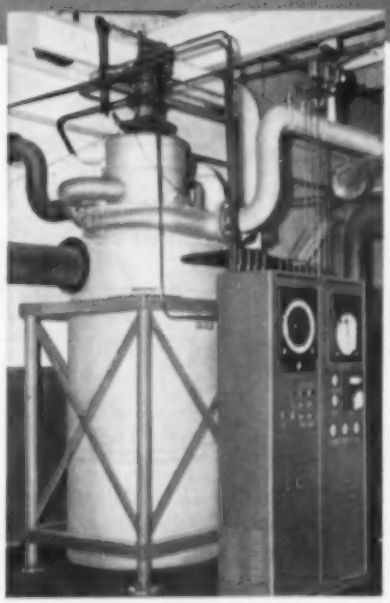

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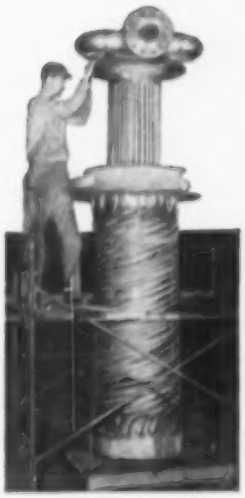

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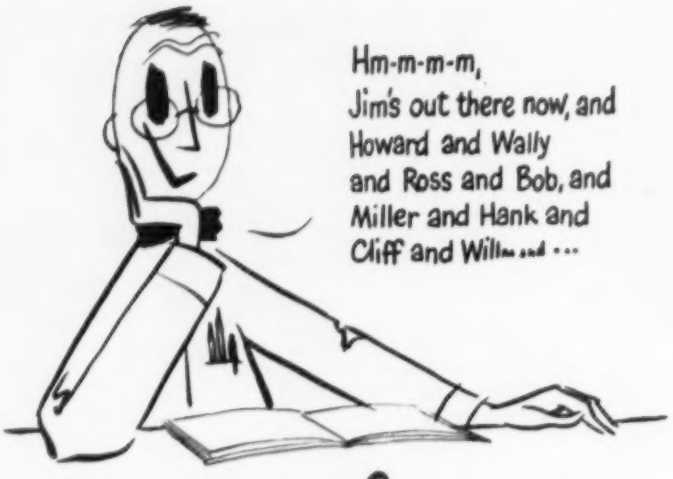

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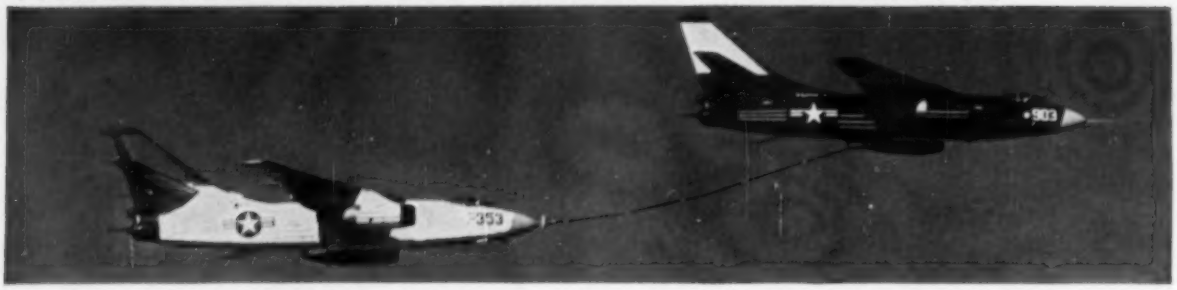

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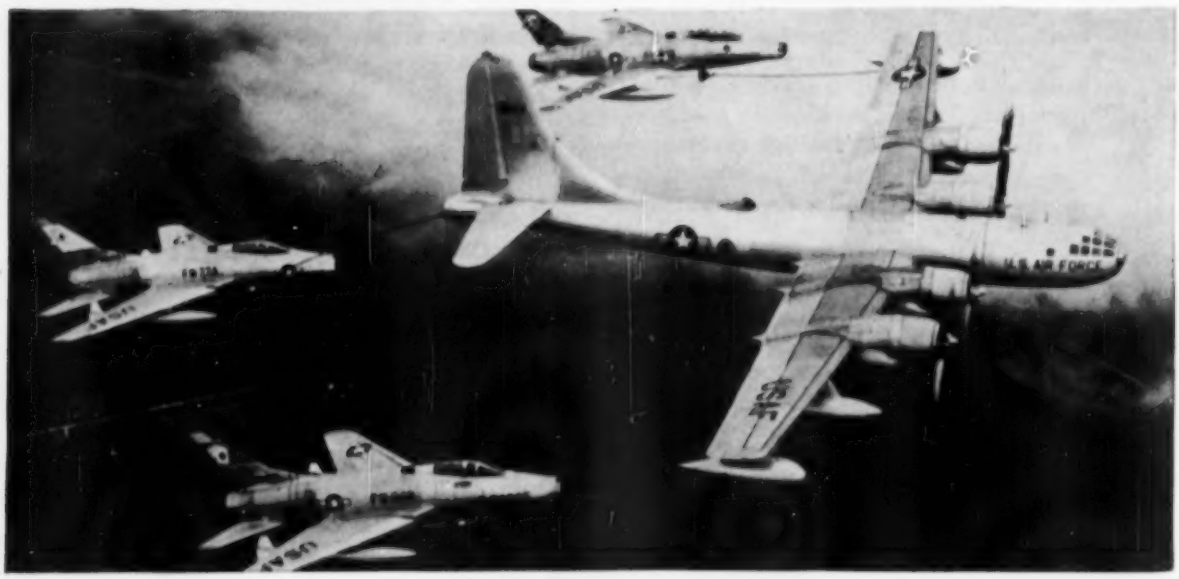

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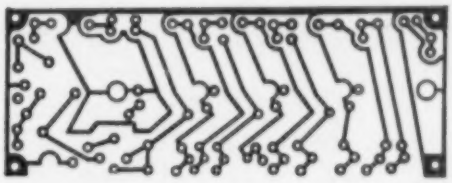

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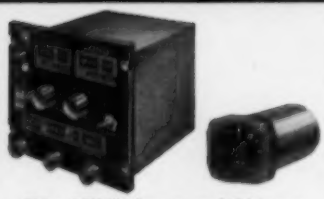
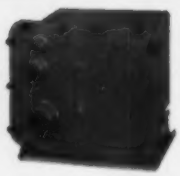


FICo ASN-7 Course and Distance Computer System — indicator and control are shown. Can be provided with polar capabilities.



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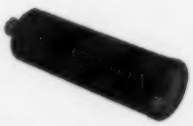

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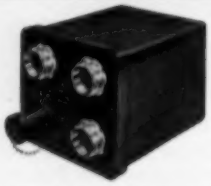

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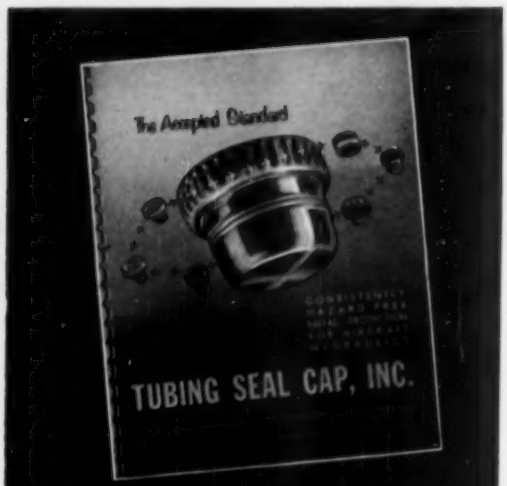

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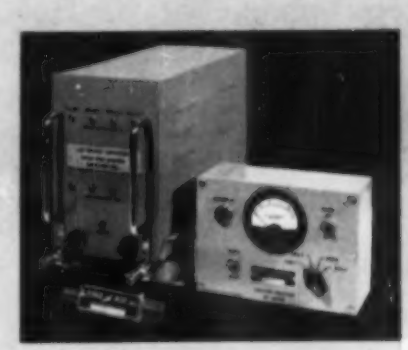

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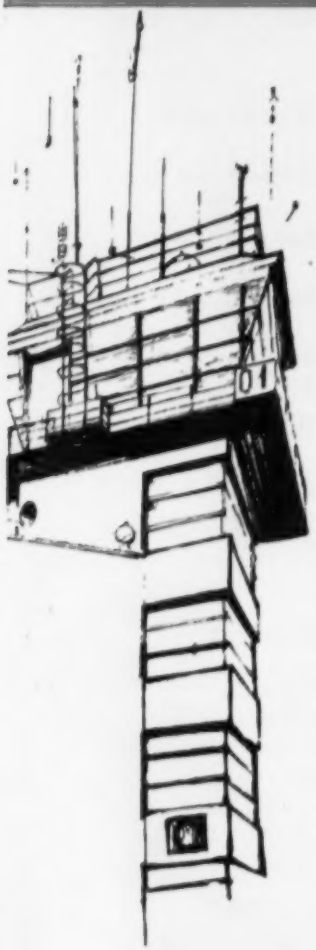

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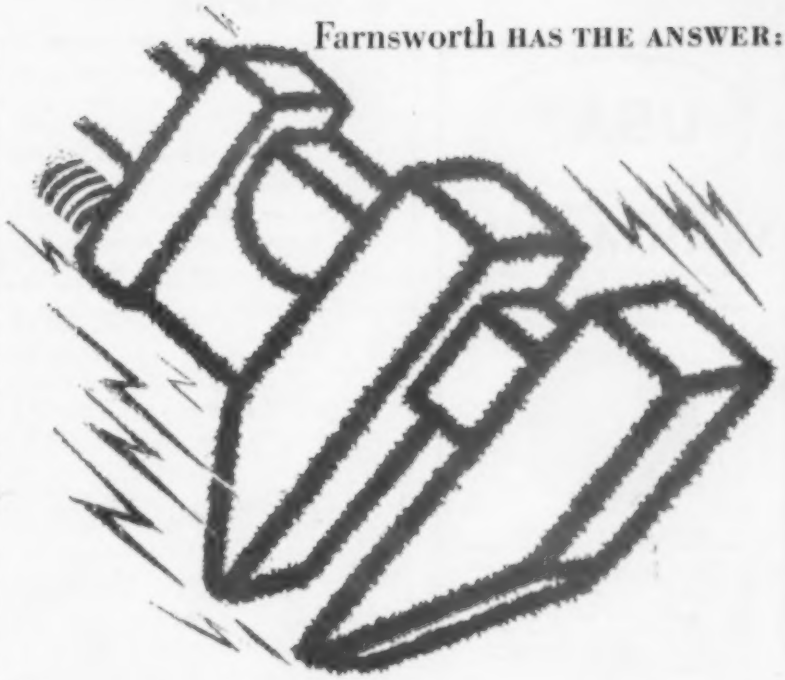

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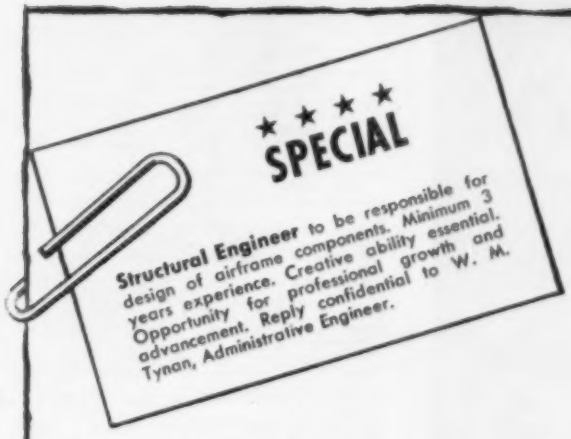
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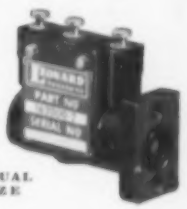

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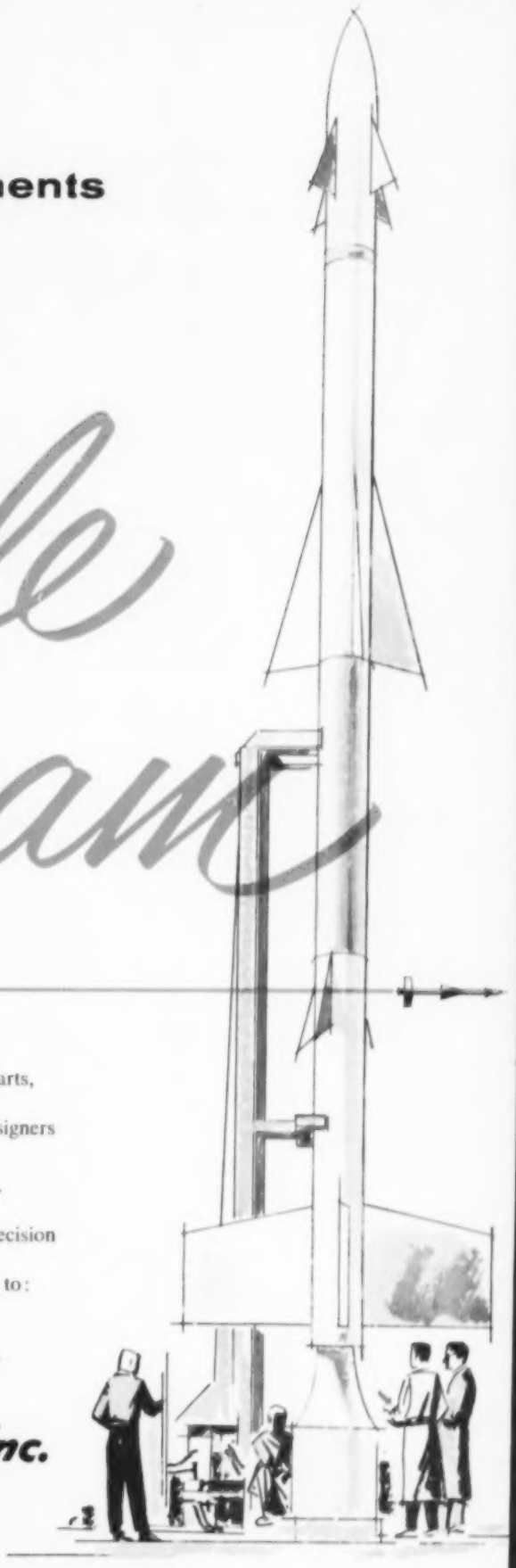

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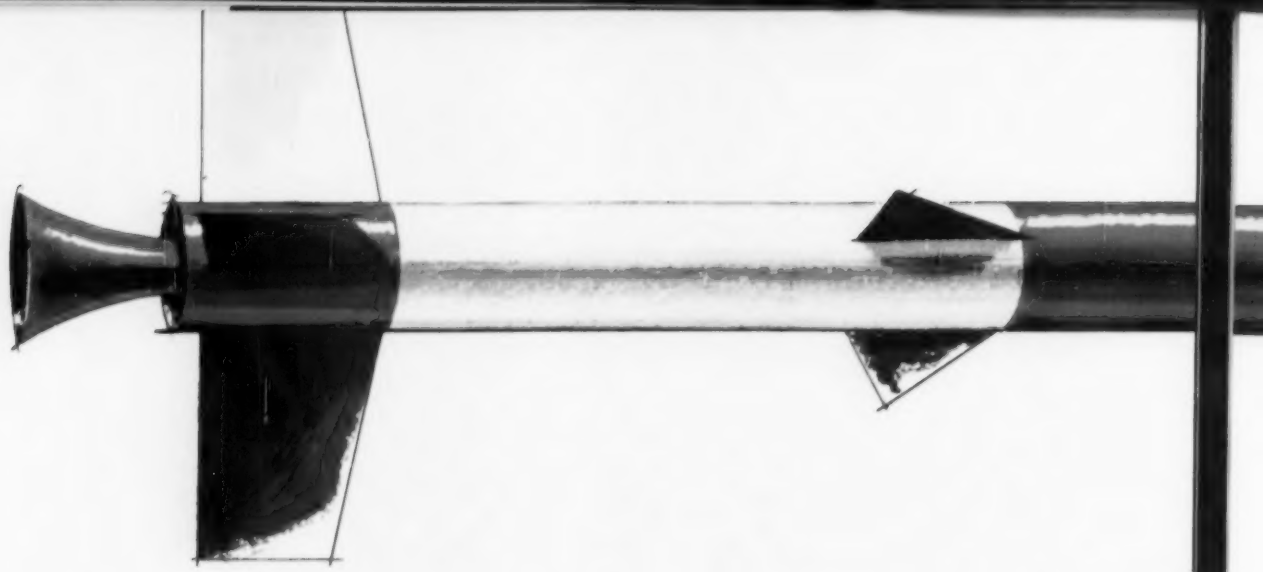

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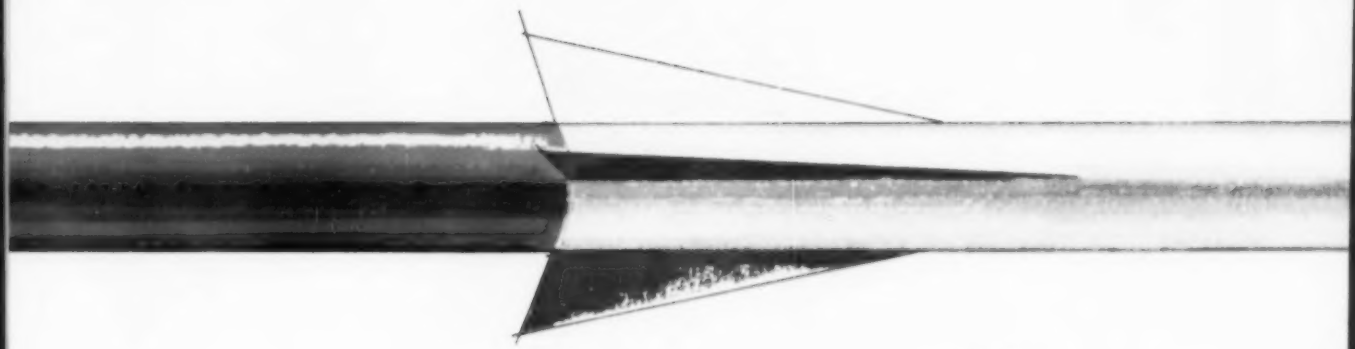

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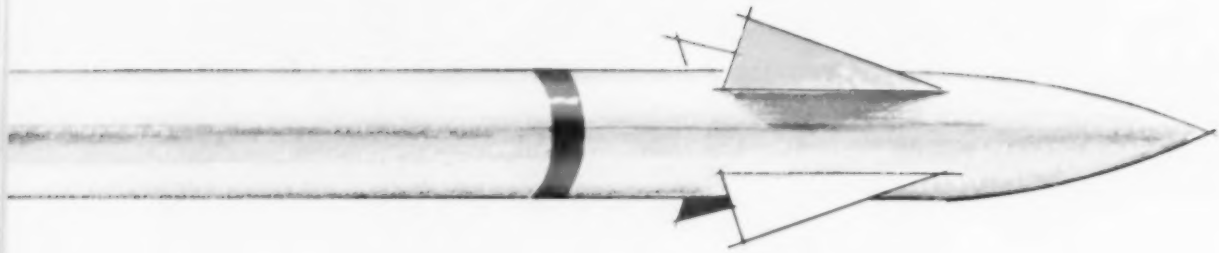

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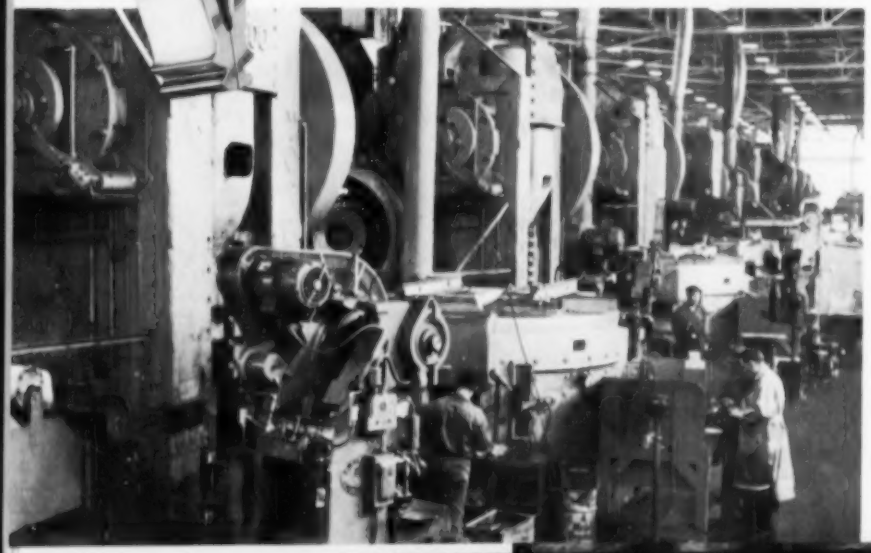

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Mahon Hits Military 'Duplicative Waste'

By Katherine Johnsen

Washington—Demands for "the elimination of duplicative waste" among the armed services highlighted congressional debate last week on the Fiscal 1958 defense budget.

Rep. George Mahon (D.-Tex.), chairman of the Appropriations Subcommittee on the Armed Services which cut the $36 billion asked by President Eisenhower to $33.5 billion (AW May 27, p. 31), led the attacks on duplication, declaring that "the time has come to tear down the costly Iron Curtain which separates the services." Mahon urged the House to vote for his group's $2.5 billion reduction, including a reduction of $354 million in Air Force funds for aircraft and related procurement and a $120 million cut in Navy aircraft and related procurement funds.

Rivalry 'Dangerous'

Mahon termed rivalry among the services for control of missiles projects "unwholesome and dangerous." He added:

"Able and ambitious officers who have devoted their careers to one of the three services are questioning whether they will have a place in the sun in the 1960s or will their careers go into decline?

"The present presumption is that any service which fails to have a part in the utilization of intermediate range and intercontinental ballistic missiles will be relegated to a lesser role. . . . We must make it possible for our men in uniform to set aside their vested interests and be somewhat secure in their careers."

Advocating "something approaching a merger," Mahon said that "the means of locomotion and movement is no longer a valid basis" for determining the structure of the military services.

"The Army wants a strategic-type missile so it can attack distant targets and will not be dependent on the Air Force even for reconnaissance.

"The Navy wants a strong air and missile capability to take care of its own strategic needs and concepts.

"The Air Force may well want to keep its strategic aircraft mission even after missiles have replaced the strategic mission of manned aircraft. . . ."

Vinson's Defense

Rep. Carl Vinson (D.-Ga.), chairman of the House Armed Services Committee, challenged the attacks on duplication and told his colleagues that it is "a wishful theory that more centralization of power brings about savings. . . . "We hear much about duplication of efforts—I do not question for a moment that there is duplication of effort—but it is a competitive type of duplication that assures this nation military supremacy in the quality of its weapons.

"There has been altogether too much misguided criticism of so-called competition between the armed forces, particularly with respect to missile development."

Meanwhile, on the Senate side of the Capitol, the secretaries and chiefs of staff of the services appealed to the Senate Appropriations Committee to restore the heavy reductions in what they have called their "minimum"

Military Aviation Procurement Funds

Unobligated balances totalling over $8.7 billion for new guided missiles, aircraft and parts contracts were reported by the Defense Department as of April 1. Unexpended balances totalled over $21.2 billion. Details released by the Department of Defense include:

OBLIGATIONS
(000 omitted)

	Obligations July 1, 1956, Through March, 1957	Unobligated Balance April 1, 1957
Aircraft and Parts		
USAF	4,754,708	4,455,184
Navy	1,487,863	1,694,996
Army	43,797	164,576
MDAP	447,669	870,365
TOTAL	6,734,027	7,185,121
Guided Missiles and Parts		
USAF	1,406,612	1,014,322
Navy	323,590	214,539
Army	402,474	136,676
MDAP	.....	170,032
TOTAL	2,132,676	1,535,569
Electronics and Communications Equipment		
USAF	297,963	470,211
Navy	98,600	123,138
Army	82,377	102,925
MDAP	56,946	337,211
TOTAL	535,886	1,033,485

EXPENDITURES
(000 omitted)

	Expenditures July 1, 1956, Through March 31, 1957	Unexpended Balance April 1, 1957
Aircraft and Parts		
USAF	4,178,955	11,227,651
Navy	1,395,001	4,703,182
Army	123,697	316,799
MDAP	593,579	1,102,174
TOTAL	6,291,232	17,349,805
Guided Missiles		
USAF	972,846	2,184,532
Navy	171,747	602,382
Army	484,328	941,450
MDAP	.....	170,032
TOTAL	1,428,921	3,898,396
Electronics and Communications Equipment		
USAF	390,743	1,057,422
Navy	77,909	294,220
Army	148,673	441,190
MDAP	112,159	359,622
TOTAL	729,484	2,152,454

budgets made by the Mahon subcommittee. Their appeals, however, were met by a charge from Sen. Stuart Symington (D.-Mo.), former Secretary of the Air Force, that "there is not much cooperation by the heads of the Pentagon" to eliminate overlapping activities.

Other highlights of debate on the defense program were:

• **Sen. Henry Jackson** (D.-Wash.), a member of the Senate Armed Services Committee and Joint Congressional Atomic Energy Committee, urged the President to appoint a "Commission on Ballistic Sea Missiles" to determine whether sufficient emphasis is being placed on missile-equipped, nuclear-powered submarines. Noting that the Navy is moving forward with its Polaris intermediate range ballistic missile on a drawn-out time schedule, Jackson said, "I believe we may be neglecting one ballistic missile system which could give us a quantum jump upward in our military deterrent power." He added:

"An IRBM launched from an ocean platform could have the same target coverage and the same military effect as an ICBM launched from our own country. . . .

"A massive surprise missile attack, skillfully executed by the Soviets, might actually knock out most of our Strategic Air Force and much of our land-based missile capability before we could retaliate."

• **Rep. Errett Scrivner** (R.-Kans.), a member of House Appropriations Committee, called for a realignment of the services from the present ground-sea-air alignment into strategic, tactical, and defense commands.

Army, Navy, and USAF, as now constituted would only "support" these three commands.

"The strategic command," he said, "would be primarily an Air Force operation, but it would include Navy carrier task forces that might have a strategic capability . . . and also the long-range missile capabilities of any of the services including the capability of launching missiles from submarines offshore.

"The tactical force would be predominantly Army but would include close air support, short range tactical missiles, the airlift service transport capability and the job of keeping shipping lanes open to the areas where such tactical forces may be involved . . .

• **Rep. Clarence Cannon** (D.-Mo.), chairman of the House Appropriations Committee, urged drastic reductions in Army and Naval forces. Cannon said the "Army is no longer of any use in time of war except in occupying territory taken from the air and in enforcing martial law. . . .

"Our only Army problem in event of war would be how to get our token forces out of Europe and even that would be doubtful. . . ."

Russia Echoes Air Force Claims On Effectiveness of Army Nike

Washington—Soviet Union last week agreed with USAF's estimation of the Army's Nike Ajax air defense missile system.

An article in "Sovietskaya Aviatsia," Russian aviation newspaper, minimized Army reports of the missile's effectiveness, declaring that tests were conducted against "obsolete piston-engined planes flying at speeds of 200 mph. Actually, it has scored hits against Ryan OQ-2 Firebee drones traveling at 500 kt. (AW June 4, 1956, p. 26).

Parts of the article were almost direct paraphrases of charges made by the Air Force last summer in its now-lost fight to equip airbases with its own Talos defense missiles which have twice the range of the Ajax.

As the Air Force did (AW May 28, 1956, p. 27), the article claimed that Nike Ajax could only hit targets flying at speeds of under 600 mph. Speeds of Russia's three strategic bombers, the Bison, Bear and Badger, are all believed to be over 600 mph.

Effectiveness of the radar-controlled Nike Ajax also would be "substantially lessened," the article said, "under real conditions where the speed of maneuvering planes keeps changing" and where the attacking aircraft can make "simple tactical maneuvers."

Nike's guidance system, it added, "is very complicated" and provides insufficient protection against radar interference. It further belittled the Nike Ajax by saying its performance is "very far from modern requirements because it can hit only single targets."

"Sovietskaya Aviatsia" took note of the Nike Hercules, intended replacement for the Ajax which will be equipped with an atomic warhead, but said "these efforts are far from completion." The Hercules is now in production and is scheduled to become operational within the next two years.

"As it now exists," the article added, "the highly praised Nike system is far from perfect."

It made no mention of Soviet air defense missile capability, although such missiles have been observed in the Moscow area.

The Air Force, in its estimation of Nike Ajax capabilities, contended that the missile's range is so limited—approximately 25 miles—it could scarcely reach 600 mph. bombers flying at 50,000 ft. before they could release their bombs. The Bison is believed to be capable of operating at 57,000 ft.; the Bear and Badger at 50,000 ft.

Army Secretary Wilbur M. Brucker and Army Chief of Staff Maxwell D. Taylor rebutted Air Force charges with the claim that the Nike Ajax can knock down any plane now in existence.

Army spokesmen last week also denied the Soviet magazine's charge that the missile has little "protection against radar interference" with a statement that it "can't be jammed."

Martin Bullpup Evaluated

Kansas City—Martin Bullpup, new air-to-surface missile, is currently under evaluation by the Navy and Air Force. Navy will use the new tactical weapon as armament for its attack aircraft. Bullpup is an 11-ft. 600-lb. missile designed for tactical use against small targets and is the winner in a competition among 14 companies.

Martin brought the Bullpup from original concept to completion of its Phase A program in less than two years. Status of the new missile was revealed last week by Vice Adm. W. V. Davis, Jr., deputy chief of naval operations for air, at the annual convention of the Aviation Writers Assn.

Bull pup is designed for tactical use by fighter and attack aircraft against such small targets as tanks, ships and bridges. Navy needs the missile to provide accuracy on small targets without exposing aircraft to the heavy ground fire like that experienced in Korea on low-level bomb and rocket missions.

In an effort to get a relatively cheap, effective weapon quickly, Davis said the Navy considered design simplicity and use of techniques well within the state of the art to be basic ground rules. Final weapon system had to be compatible with current and future light attack aircraft and suitable for carrier use or shore-based Marine Corps operation. Bullpup will provide significantly greater attack capability primarily because of "the increased accuracy with which the warhead can be delivered on the target," Davis said.

Martin will produce the new missile at its Orlando, Fla., plant.

Davis also pointed out that Sparrow III is "coming along" as a replacement for the Sparrow I air-to-air missile. Sparrow III is 12 ft long, weighs about 350 lb. and reaches a speed 1,500 mph. faster than the speed of the launching aircraft within seconds after launching, he said.

BERNARD SIMONS, Senior Project Engineer on the Convair 880 Jetliner. A graduate of the University of Detroit, Mr. Simons joined Convair-San Diego nine years ago as an engineering designer. He is respected for his contributions to jet airliner advancement — as well as his ability to develop engineering talent.

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Federal Aviation Agency Proposed Now

Washington—Effort will be made within Congress this year to establish an independent Federal Aviation Agency immediately, foregoing the interim Airways Modernization Board proposed by Presidential Assistant Edward P. Curtis (AW May 20, p. 26).

Such a move is favored by Sen. Mike Monroney (D.-Okla.), chairman of the Senate Commerce Committee's aviation subcommittee, who fought last year to make the Civil Aeronautics Administration independent of the Commerce Department.

Objections to Curtis Plan

Curtis has taken the position that, because of the main reorganization problems involved, the target date for the Federal Aviation Agency should be put off for three years to 1960. In the interim, he proposes establishment of the Airways Modernization Board which would develop a common airways navigation system (AW Apr. 15, p. 29). The board would be comprised of the Secretary of Defense, the Secretary of Commerce and a third member—the chairman—to be appointed by the President but not connected with any government agency.

The two basic objections of Monroney and other members of the Senate Commerce Committee to this intermediate step are:

- **Neither the Secretary of Commerce** nor the Secretary of Defense—considering their other duties—could be expected to devote sufficient time to the activities of the board, with the result that representatives without sufficient influence would participate.
- **The chairman,** who would be the deciding member of the board on civil-military conflicts, would not have authority to put his recommendations into operation.

Curtis Endorsements

In testimony during the closing hearing of the Senate Commerce Committee on legislation establishing the Airways Modernization Board, Clarence Sayen, president of the Air Line Pilots Assn., urged prompt establishment of an independent civil aviation agency. He said:

"It has long been our view that the responsibility for aviation facilities should be in a single agency with a single head. . . . We were pleased to note that in the complete reports of the Curtis Committee this conclusion is recognized. However, in connection with the AMB legislation . . . a tripartite board is recommended. It would appear practical that the organizational concept envisioned for the solution of long-run problems would also be the most efficient for the solution of immediate problems."

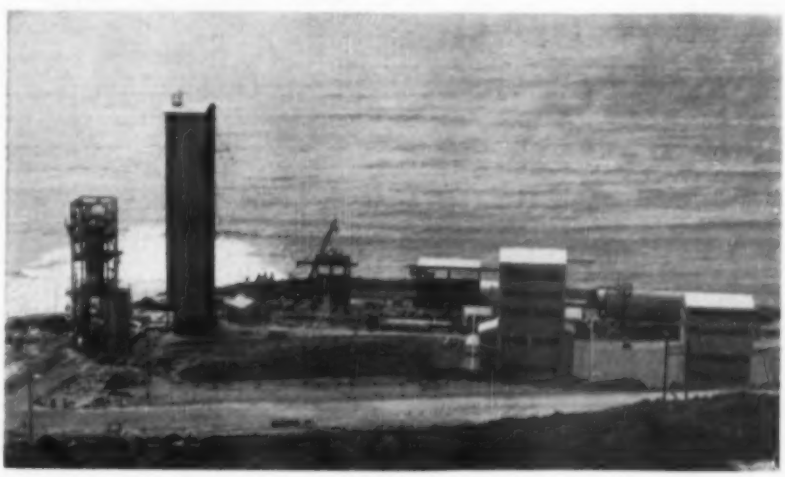
Sayen warned that increasing introduction of Century series jet fighters into Air Force wings will require blocs of air space 10 by 15 miles at numerous locations and increase the necessity for decisive action on the civil-military division of airspace, now impossible through the Air Coordinating Committee (AW May 27, p. 40).

Curtis' proposal was endorsed by:

- **Stuart Tipton,** president of the Air Transport Assn., said the agency represented "an effective means of meeting an urgent problem, one which is slowing down the development of aviation." Tipton said the Airways Navigation Development Board, which the AMB would supplant, had representatives of "two competent agencies, trying to work together but often pulling in opposite directions. The marvel is that

Atlas Test Stands

First photographs of test facilities for Convair Atlas intercontinental ballistic missile include test tower for rocket engines and missiles systems in a secluded military reservation in Sycamore Canyon, northeast of San Diego, Calif. (top). Components for the missile are tested in a seaside tower at Point Loma, also near San Diego. Actual launchings will be carried out at Patrick AFB, Fla.



they accomplished as much as they did."

• **William Lawton,** executive director of the National Business Aircraft Assn., described the AMB as "a sincere attempt to bring all air space users into an effective, cooperative and decision-making body." The AMB, he said, will "provide an instrumentality now lacking in our present governmental and non-governmental aviation advisory bodies . . . to make decisions. . . ."

• **J. B. Hartranft,** president of the Aircraft Owners and Pilots Assn., endorsed the "intent" of the proposed board but urged that assurances be added to legislation to provide civil users of air space with a "proper voice."

Interim Mexico Route Asked for American

Washington—Civil Aeronautics Board asked the State Department last week to designate American Airlines as the "interim" U.S. flag carrier to operate a new Dallas-San Antonio-Mexico City route pending the completion of the Chicago-Mexico City route case.

The Board said it had deferred its decision as to whether Braniff Airways or American should be selected to operate the route on a permanent basis. Both airlines now hold authority to provide the service, and the CAB must name a single carrier to operate the route in accordance with the terms of the recently signed bilateral agreement between Mexico and the U.S. (AW Mar. 25, p. 43).

Decision to defer the case was taken in "the light of matters presented at the oral argument" and because of the need for the "evidentiary record" on which to base conclusions, the Board explained. It said the case could not be completed prior to June 5, the date on which the bilateral agreement becomes effective, because of procedural matters.

The Board emphasized that the designation of American as the "interim" carrier would not be a factor in reaching a final decision as to which of the two airlines should be awarded permanent authority to serve the route.

Mexicana Withdraws New York Application

Mexico City—Aeronaves de Mexico, in which former Mexican President Miguel Aleman has controlling interest, appears certain to be designated as the Mexican carrier to operate the lucrative non-stop route to New York.

Aeronaves' selection was assured when its only competitor for the run, Compania Mexicana de Aviacion, withdrew its application May 15.

Atlas Firing

Washington—Rep. James T. Patterson (R.-Conn.) reported last Tuesday that the first test firing of the Atlas intercontinental ballistic missile from Patrick AFB, Fla., would be made before the end of the week as predicted by Aviation Week on May 20 (page 23). Patterson said the missile was scheduled to reach an altitude of 700 miles, "turn on a curved right angle and proceed under continuously controlled flight in a southeasterly direction" for a distance of 2,200 miles.

Rumors that Aeronaves was seeking to merge with Mexicana were strongly denied by both companies. Observers point out that Mexicana, Mexico's largest airline, would have little to gain by merging with Aeronaves. Mexicana, which is owned 42% by Pan American World Airways, annually makes a profit. Aeronaves is generally considered to operate at barely the break-even point. Pan American owns 20%-22% of Aeronaves. Whereas Mexicana already is an experienced international carrier, operating to Los Angeles and Havana, the New York run will be Aeronaves' first venture into the international field.

Although Aeronaves is expected to be formally designated before June 1st (the bilateral air agreement becomes effective June 5) it is not expected to begin its daily non-stop service to New York until around November 1.

Confident of being designated for the New York run, Aeronaves several months ago bought two Bristol Britannia 302s for a reported purchase price of $7.4-million dollars. This was said to be financed by the Manufacturers Trust Co. of New York ($1.3-million dollars) and by Air Finance, Ltd., of England. Aeronaves is to receive the first Britannia Aug. 20 and the second toward the end of September. Negotiations reportedly are under way for a third Britannia to be delivered next year.

A factor in the Aeronaves purchase of Britannias is the fact that early this summer the Bristol Aeroplane Company of Canada (1956), Ltd., Montreal, is to open a $500,000 aircraft engine maintenance and repair shop at the Mexico City International Airport to overhaul engines up to 3500 hp. Until recently, Aeronaves operated a repair shop in Torreon which could handle engines up to 1,500 hp. All more powerful engines were overhauled in the United States.

Aeronaves sold its Torreon shop in exchange for an intetest in the new Bristol shop, which is to be Bristol's first engine overhaul affiliate in Latin America.

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Why the Missile Engineer Never Missed Mail Call

Vought's Regulus II missile took shape just a short walk from the desks of its developers. Engineers handled the new hardware and monitored tests in person — literally flying the big missile on the ground at Dallas. It was a convenient arrangement while it lasted.

Then a big USAF Globemaster landed and taxied to Vought's Experimental Hangar. The missile was winched aboard and airlifted to a desert site for flight tests. By nightfall there was a 1,000-mile rift between Regulus II and home base.

Joe Boston was ready to step into this gap. As Project Assistant for Field Liaison, he'd already equipped Vought's desert crew for extensive flight tests. Now he'd make sure that test data and hardware flowed uninterrupted from the desert to Vought. High-speed feedback of facts on one flight could influence the success of the next.

Mail from the desert poured in to Joe at Vought. From project men at the flight test site came parts for immediate rework and return. From the flight test crew's mobile ground station came rolls of telemetered brush records. From the recoverable Regulus itself, came packets of oscillograph data. And from Field Service — for repair or replacement — an occasional wrench or relay.

Joe served as clearing house and consultant. Flight data was reduced and released to design and support groups. It revealed not only missile performance, but the temperatures and pressures of a strange new environment. When data pointed toward design changes, Joe's time and cost estimates helped specialists reach decisions.

Thanks to Vought's fast overland relay of hardware and data, the records of one flight were decoded and digested in time to improve the next hop. Dividends in performance and reliability were obvious after six flights had been logged by Regulus II.

All six had been flown by one vehicle.

Chance Vought uses comprehensive testing and data analysis to assist the engineer through unexplored problem areas. Test facilities strengthen every phase of the development cycle, and procedures are aimed at feeding data quickly into the engineering process.

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Service Debate on Airlift Authority Settled by Compromise Decision

Washington—Defense Department has settled a seven-month-old controversy over domestic air carrier contracts with a compromise decision:

• **U. S. Air Force and Navy** will be allowed to continue control of traffic on Logair and Quick Trans routes.

• **Military Traffic Management Agency,** the single manager for traffic management within the U.S., must first determine that the contract service is necessary.

• **Actual negotiation for required** contract air services will be carried out by the single manager for air lift service, who happens to be the Secretary of the Air Force as administrative chief of the Military Air Transportation Service.

Decision to give the relatively new Military Traffic Management Agency (MTMA) power to evaluate the necessity for special contract routes was made in a memorandum from E. Perkins McGuire, Assistant Secretary of Defense for Supply and Logistics.

From the time that MTMA went into business and prepared to assume responsibility for air carrier contracts there was undenied resistance from the Air Force and Navy to the concept that the new management agency would determine how logistic items would be moved. (AW Oct. 15, p. 32; Jan. 7, p. 26)

Under terms of the new McGuire directive, MTMA retains responsibility of evaluating the need or desirability for long-term contract services on the basis of requirements.

It also will evaluate the quality of services rendered by contract carriers and the manner in which USAF and Navy use the service.

"This means," a MTMA spokesman said, "that if the Air Materiel Command needs a Logair route to move engines or other high-dollar-value items they can have it. But if they use it to carry mops, MTMA can stop the operation."

In practice, outside evaluation of how a contract air service is used is expected to result in more efficient use of the capacity made available. There are two major possibilities:

• **Elimination of some routes** where MTMA finds specialized service is not necessary or that existing commercial carriers can handle the traffic.

• **New proposals** from the contract carriers themselves and scheduled airlines for services that will make segments of the Logair and Navy's Quick Trans operations unnecessary.

USAF's Logair, managed out of AMC, Wright-Patterson AFB, Ohio, is the largest scheduled air cargo operation in the country, flying 200 million freight-ton miles a year.

In Fiscal 1957; it paid $21 million for this service to five contractors.

Navy's Quick Trans is run by a single operator, providing five roundtrips weekly, coast-to-coast.

Air Force Queried On J47 Overhaul

Washington—USAF's decision to channel some of its dwindling J47 engine overhaul business into the Utica Mich., plant of Studebaker-Packard Corp., under lease to Curtiss-Wright Corp., was challenged last week by Rep. William Hess (R.-Ohio), ranking Republican on the House Armed Services Investigating Subcommittee. Hess also asked the Air Force to supply him with detailed information as to why the decision was made.

The overhaul work, which had been

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performed at two USAF bases and General Electric Co., manufacturer of the engine, was extended to the Utica facility for "the benefit of competition and broadening of the production base" (AW Aug. 13, 1956, p. 26).

In a letter to Air Force Secretary James H. Douglas, Hess said he doubted that "it stood to the financial benefit of the taxpayers to divide the diminishing workload into four instead of three parts."

Defense Announces Expenditure Curbs

Washington—Defense Department has taken new steps to keep military expenditures within the bounds of appropriations and available funds.

In a directive that the Army, Navy and Air Force must put into effect early this month, Defense Secretary Charles E. Wilson has ordered them to halt procurement that is unauthorized or for which funds are not available for obligations.

The directive further says that procurement negotiations now under way that do not meet these standards must be rescinded or modified to conform to the new policy.

A Defense spokesman told AVIATION WEEK that the new order is not directed at any particular branch of the services or toward any particular procurement program. He indicated that the directive is considered a reiteration of existing policy and that it was issued to insure compliance and protect the department from possible congressional criticism if the existing rules are ignored or overlooked.

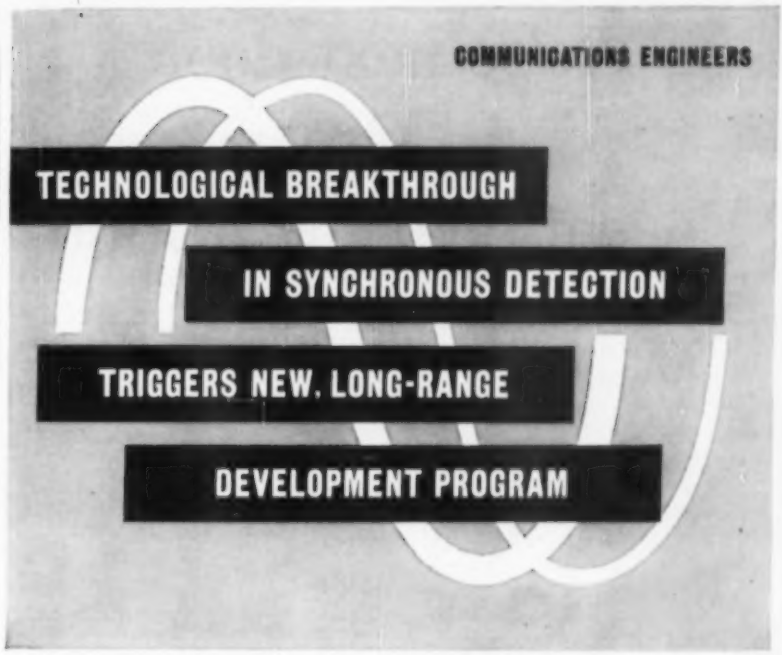
Exceptions to the new rule are procurements from research and development appropriations and items specifically excepted by the Secretary of Defense.

Missile Control Unit Announced by Army

Washington—New electronic antiaircraft missile control system capable of analyzing both air attack and defense plans has been developed by Burroughs Corp. under Army contract.

Army says the system can perform 136,000 mathematical steps in less than a second and provides this information:

- **Time required for a missile** to travel from the battery to its bursting point.
- **Time battery needs** to carry out its assignment.
- **Point on intercept.**
- **Whether target is within** effective range.
- **"Kill" probability** of a battery-target assignment.
- **Percentage of total bomb damage at-**



Engineers have long believed that AM, as a modulation process, is capable of far better performance than has been obtained from conventional systems. Recently a technological breakthrough was achieved by the G-E research staff in this area—a new Synchronous Detection Double Side Band System.

So impressive was the demonstration of General Electric's prototype equipment, that the go-ahead signal was given for a projected 3-year program to develop Synchronous Detection to the product stage.

A special project group is forming now to work on Synchronous Detection at Light Military Department. The immediate need is for engineers to work on both circuit and system. The successful completion of this program will usher in new, large-scale commercial as well as military applications. Engineers who have contributed to Synchronous Detection will have many opportunities before them.

For the full technical story, send for your copy of "SYNCHRONOUS COMMUNICATIONS SAM-DSB"

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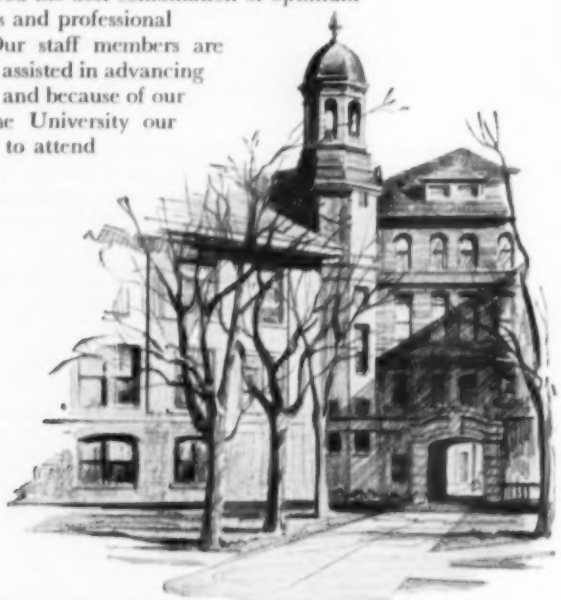

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tacking planes are capable of inflicting.
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Heart of the system, which was originally conceived by the Army's Signal Engineering Laboratories, Fort Monmoth, N. J., is a high-speed real time electronic digital computer. The unit, 29 ft. long and over 7 ft. high, is housed in seven cabinets and is equipped with two control panels.

Terrier II Size Hinted In Pyroceram Radome

Indication of the size of Terrier II missile is supplied by a radome nose which Corning Glass Works, Corning, N. Y., displayed in announcing its new Pyroceram material. The Pyroceram nose, which can withstand up to 2,400F temperatures and large rates of thermal shock, is being considered for the Navy-Convair missile.

From the size of the Corning Pyroceram nose radome, Terrier II will be about double the size of the Terrier I. Obviously the original shipboard beam-rider guidance system will be supplemented by radar homing for the missile, which Navy plans to use aboard frigates.

Pyroceram is a Corning invention which uses a post-forming reheat to first form crystals of finely dispersed "nucleating agents" throughout glass which in turn induce the growth of crystals in the normally amorphous glass. The process is similar to another CGW invention, the use of copper, silver or gold dispersions in glass to form photosensitive glass.

Formation of crystals transforms the glass into a harder, more temperature resistant substance with a strength to weight ratio equal to annealed (75S) aluminum alloy.

Unfortunately the brittleness of glass is retained.

It is this brittleness which is causing

Chief USAF Scientist

Washington—Dr. George E. Valley, Jr., Massachusetts Institute of Technology physics professor and former associate director of Lincoln Laboratory, will become chief Air Force scientist sometime this fall.

Dr. Valley, a member of the Air Force Scientific Advisory Board from 1946 until 1955, succeeds Courtland D. Perkins who will return to Princeton University as chairman of the Aeronautical Engineering Department after serving out a one-year assignment in Washington.

some hesitancy on the Terrier II project. A saving factor might be that Pyroceram is not as surface-scratch sensitive as glass and, in case of failure, shattered fragments are not so dangerous to handle.

Unlike metals and glasses which loose their strength progressively with rising temperatures, Pyroceram has the unusual characteristic of holding on to its room temperature strength almost all the way to 2,400F where it fuses. Another apparent virtue is that it can be mass formed by all the current techniques known to glass manufacture, then altered to its crystalline form.

Britain Flies Its First Turbine Helicopter

London—Prototype of the Westland Wessex helicopter powered by the Napier Gazelle gas turbine engine has made its first flight.

The one hour and five minute flight was the first in Britain of a helicopter driven by a gas turbine engine. After initial hovering to check out control and engine characteristics, the helicopter was flown through a full range of maneuvers and speeds up to 125 kt.

The single rotor helicopter has been ordered by the Royal Navy.

News Digest

Sud Aviation's twin-jet Caravelle is welcome at Port of New York Authority airports on a permanent basis. Caravelle made six takeoffs and landings at Idlewild during demonstration tour, was checked out by acoustical engineering firm of Bolt, Beranek and Newman as comparable to present four-engine piston planes.

First production model KC-135 jet tanker-transport to come off the assembly line at Boeing Airplane Company's Renton, Wash. plant was delivered to the company's Moses Lake flight center for testing.

Ford Motor Co. Aircraft Engine Division was awarded an additional Air Force contract totaling $73,615,488 for J57 turbojet engines for the Air Force B-52 bomber and KC-135 tanker.

Hercules Powder Co. Alleghany Ballistics Laboratory, Cumberland, Md., was awarded a $3,500,000 contract by the Bureau of Ordnance for engineering and testing of experimental propulsion systems for guided missiles.

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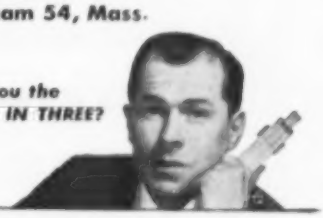

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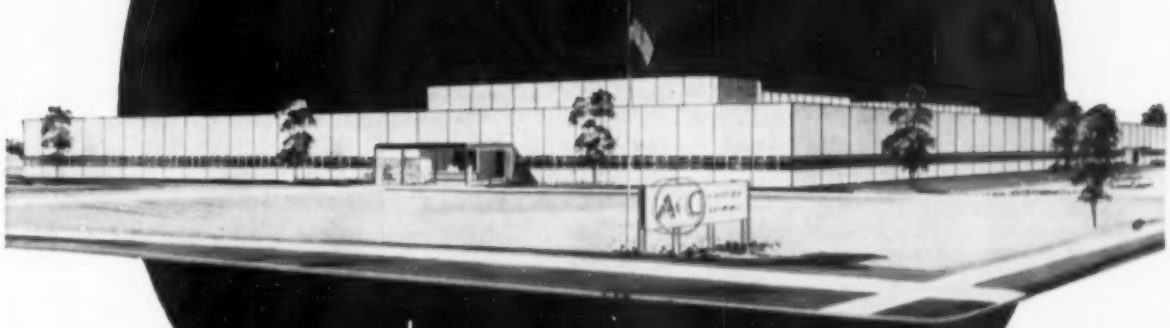

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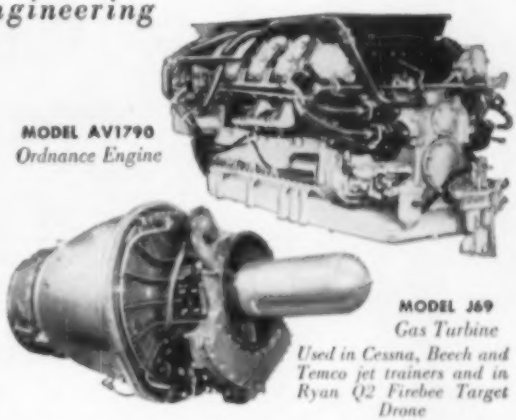

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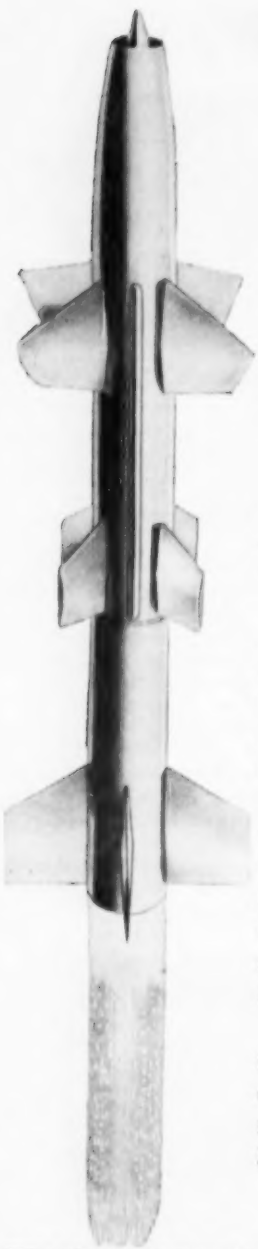

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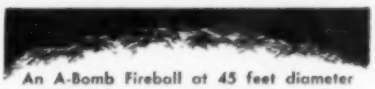

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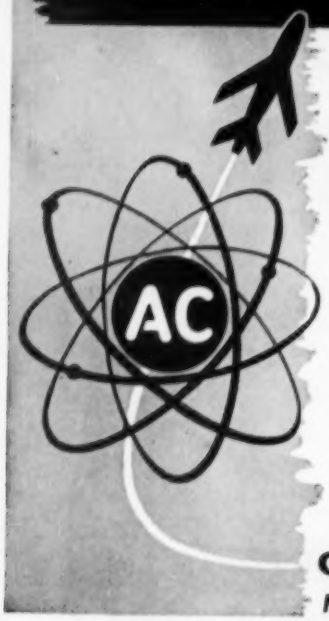

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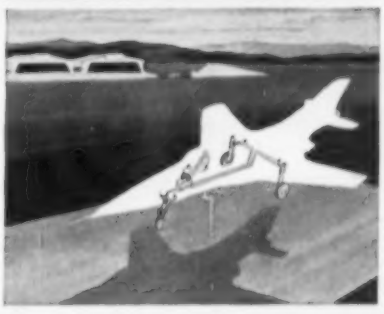

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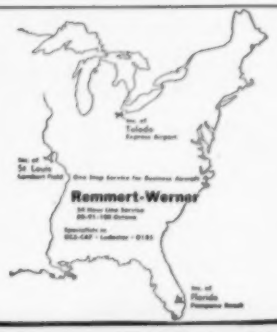

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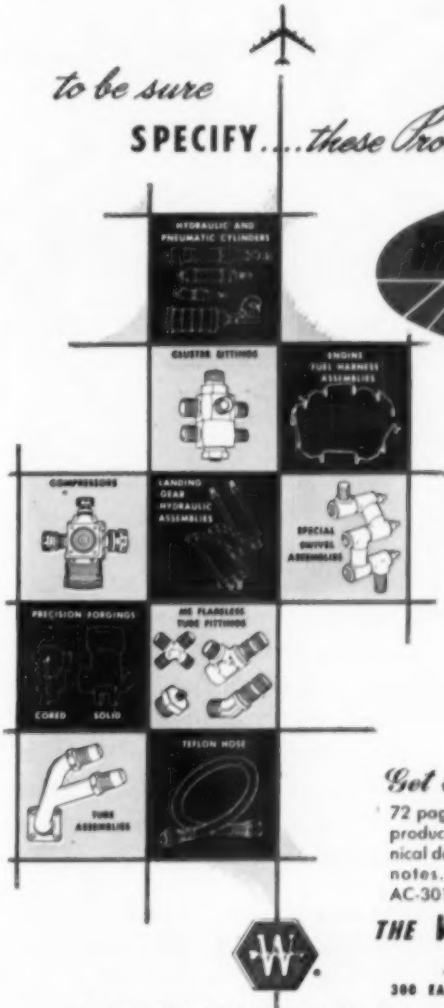

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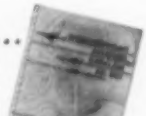

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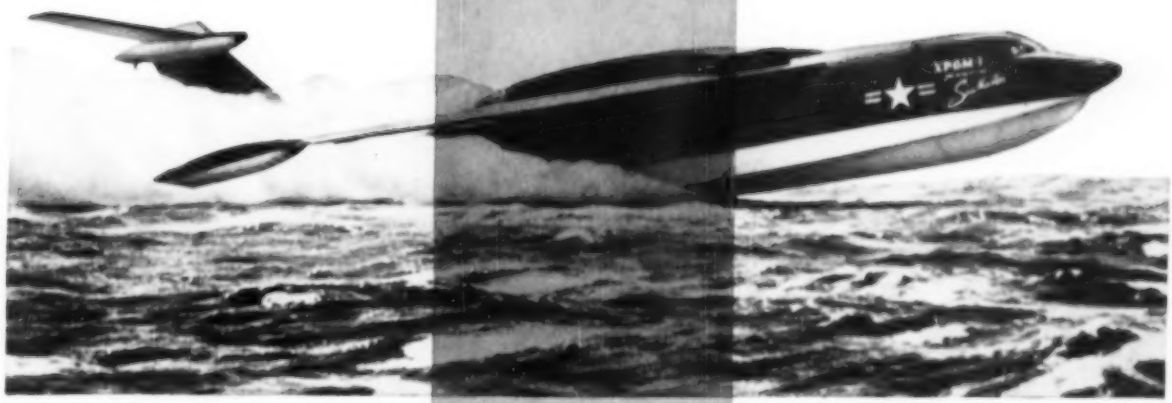

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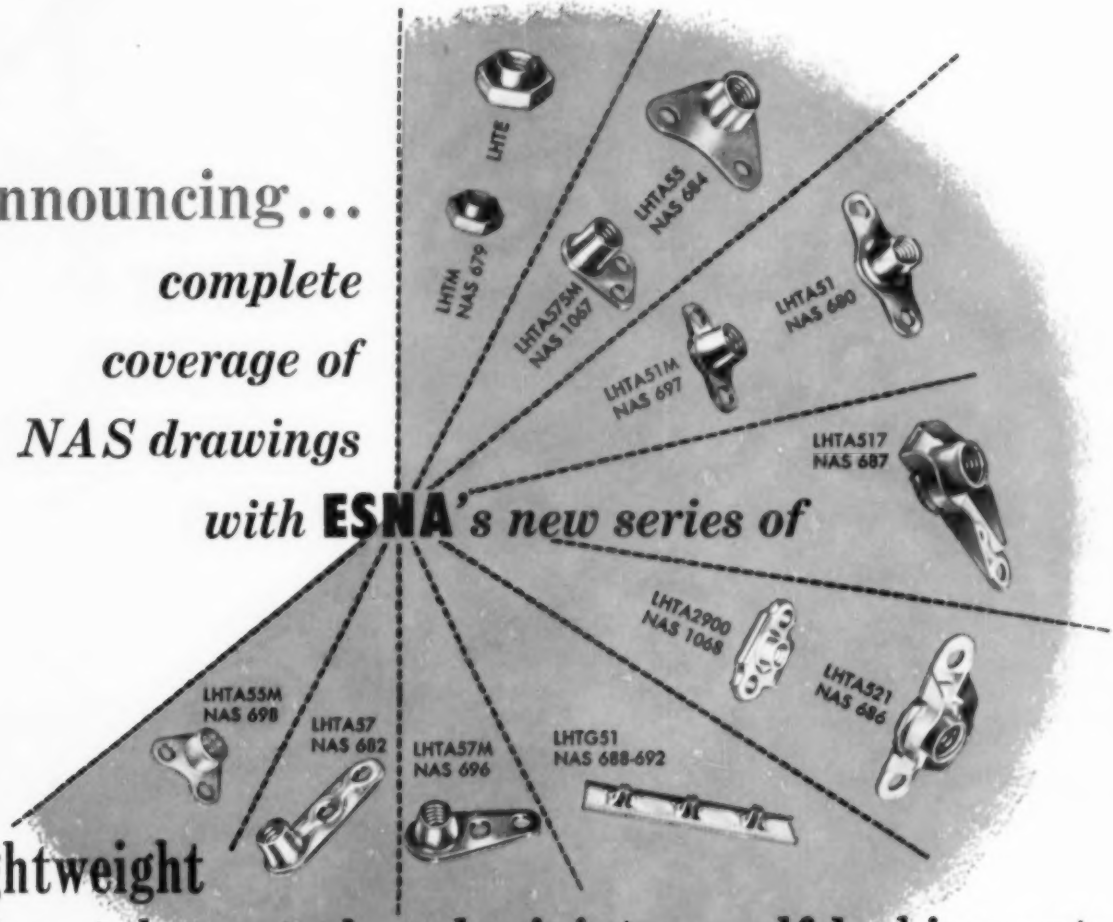

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